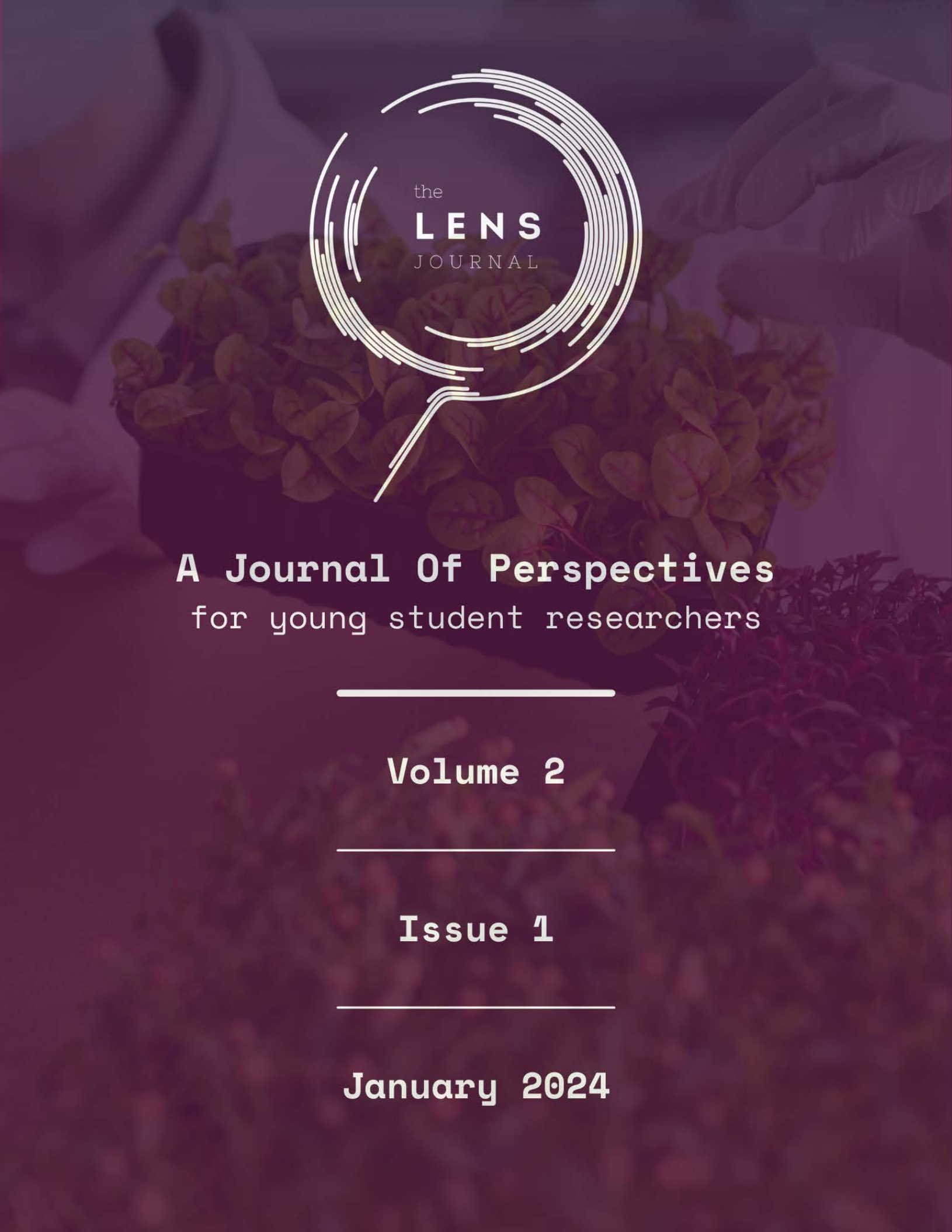


# A Journal Of Perspectives

for young student researchers

Volume 2

Issue 1

January 2024

**The Lens Journal**
*A journal of perspectives for young researchers*

Dear Readers,
It is with great excitement that we step into a new year and unveil Volume 2, Issue 1 of The Lens! Our commitment to providing a platform for young researchers to share their insights remains unwavering. This issue is particularly special as it encapsulates a diverse range of topics, from environmental challenges to an in-depth analysis of business strategy.
In this edition, we are proud to present:

1. **"Investigating the Effects of Varying Concentrations of Salinity on the Growth of Phaseolus Vulgaris"** by Aditya Nadar: This research paper explores the significant impact of salinity on agriculture, a pressing issue in the context of global freshwater scarcity.

2. **"Impact of LEGO's Corporate Culture on Innovation"** by Shambavi Nair: An intriguing case study that examines how LEGO's unique corporate culture fosters continuous innovation and growth in the competitive world of toy manufacturing.

3. **"What Are Countries Doing to Combat the Effects of Fossil Fuels?"** by Elizabeth Buxo: An insightful exploration into the global efforts to transition from fossil fuels to renewable energy, focusing on the initiatives in Trinidad and Tobago and China.

4. **"Reasons for International Concern: The Detrimental Effects of Climate Change and Pollution on the Planet's Coral Reefs"** by Rebecca Buxo: A compelling piece that highlights the critical state of our planet's coral reefs, emphasizing the need for immediate action to preserve these vital ecosystems.

In this issue, we bring you a rich mix of content, ranging from environmental studies to a deep dive into LEGO's business approach. Each article sheds light on different aspects of our world – the environmental challenges we're facing and the innovative strategies in the business world. As we explore these varied topics, we appreciate the importance of looking at issues from multiple angles. Your support and active participation as readers and contributors are what make The Lens thrive.
We're excited to hear what you think about this issue. We hope it not only gives you new information but also sparks inspiration. Let's keep building a community that's eager to learn, engage, and contribute to making a positive impact in the world.

Warm Regards,

**Ruchi Steven**
*Editor-in-Chief*
*Vol 2 | Issue 1 | January 2024*

The Lens Journal
*A journal of perspectives for young researchers*

# Investigating the Effects of Varying Concentrations of Salinity on the Growth of Phaseolus Vulgaris

*Aditya Nadar*

## Introduction and background information

At an initial glance, the water availability might not seem like an issue, but only a fraction of water is usable for regular agriculture. Only around 2.5% of water on earth is freshwater and most of this freshwater is stored in Glaciers and Icecaps, which decreases its accessibility. Around 30.1% of freshwater is found in underground aquifers and reservoirs. Only 1.3% of freshwater comes from sources such as lakes, rivers, and ice and snow. This can be seen in Image 1.

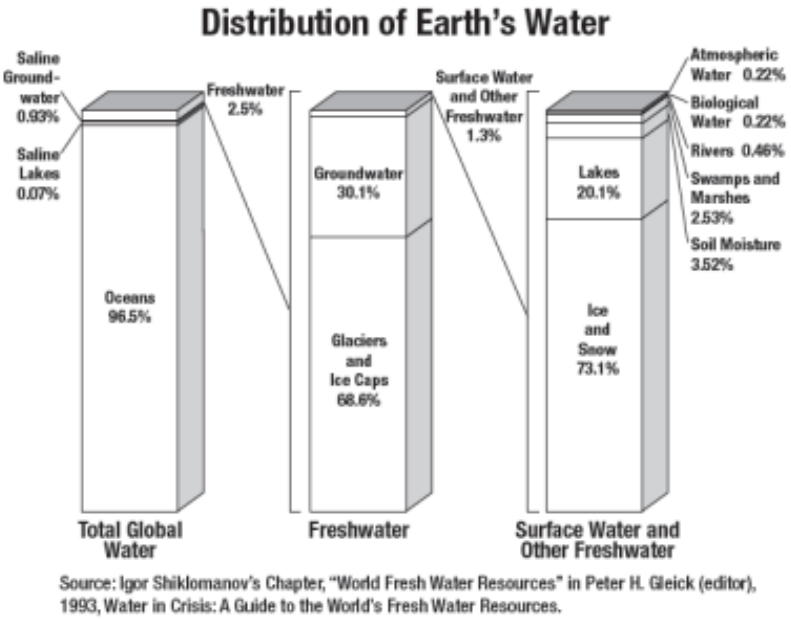


***Figure 1:*** *shows the availability of freshwater and saltwater from various sources on earth.*

Globally, the agricultural industry consumes 70% of total freshwater available[1]. In India, 91% of available freshwater is used by the agricultural industry (Benjamin Kayatz et.al 2019). This overreliance on freshwater for irrigation is an unsustainable model for the future as the freshwater from rivers are being polluted, underground aquifers are being depleted and it is harder than ever to get access to freshwater.

[1] https://www.worldbank.org/en/topic/water-in-agriculture#1

In India, the scarcity of freshwater is very severe. Part of this shortage is caused by the disproportionate distribution of resources to a large population, as 16% of the world's population lives in India, but it only has 4% of the world's freshwater resources[2]. This not only affects the general population of the country in a negative way, as 200,000 people die every year due to the lack of easy access to potable water[3]. The scarcity of fresh water also heavily holds back the agricultural industry on which roughly 50% of the population depends.

Not only has the water crisis had a wide impact on the farmers but it has also driven a lot of them to commit suicide as 7.4 percent of all suicides in India are committed by farmers[4]. This issue has escalated in recent years, as in Punjab 3-4 farmer suicides were reported every day in the local news in 2020. This seemingly one-dimensional problem has had devastating effects on thousands of farmers and their families. This grim situation made me wonder what could be a solution for this. I know that the majority of the water available in India is not freshwater but has some level of saline contamination. If we can use slightly saline water that can be tolerated by the plants then the dependency on freshwater will be reduced. Thus I was driven to pursue salinity studies for my extended essay.

Another reason for pursuing this study was the importance and relevance of this issue. This is an issue that is worth looking into, because it aims to aid the agricultural sector which makes up 18 percent of India's GDP[5] and 58 percent of the nation's population depends on the agriculture sector for their livelihood.

The salt used in this experiment is Sodium Chloride salt. This salt was specifically chosen for several reasons. Firstly, according to India's Central groundwater board, Sodium chloride is one of the most common contaminants in underground water reservoirs and aquifers[6]. Secondly, I come from and reside in the coastal regions of India, where the soil is naturally rich in sodium chloride, as studied by Arulmathi and Porkodi(2020).

Phaseolus vulgaris was specifically chosen to be studied for several reasons. Firstly, Phaseolus vulgaris is rich in protein and potassium, this is why it is consumed as a reliable source of protein by the vegetarian population here in India, which makes up 23% to 37% of the entire nation's population[7]. Secondly, Phaseolus vulgaris is widely consumed in my locale. While Phaseolus vulgaris is most widely consumed in Northern India, a lot of North Indians reside in my locale, hence it has always had a presence in my life and that is why I have decided to choose it as the plant for this experiment.

The review of the literature shows instances where low concentrations of NaCl promote plant growth instead of hindering it (Abdul Quados, (2010)), however contrasting results reveal that all concentrations of salt inhibit the growth. In light of the contrasting results, I wanted to confirm the level of salinity that can be tolerated by Phaseolus vulgaris. Hence, I formulated a research question.

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2 https://www.businessinsider.in/international/news/india-has-a-farmer-suicide-epidemic-and-farmers-are-protesting-new-laws-they-fear-will-make-things-worse/articleshow/80159707.cms

3 https://m.economictimes.com/news/economy/agriculture/rising-water-crisis-forces-indian-farmers-to-rethink-their-crops-selection/articleshow/77098970.cms

4 https://economictimes.indiatimes.com/news/politics-and-nation/ncrb-data-shows-42480-farmers-and-daily-wagers-committed-suicide-in-2019/articleshow/77877613.cms

5 https://www.ibef.org/industry/agriculture-india.aspx

6 http://cgwb.gov.in/wqoverview.html

7 https://www.bbc.com/news/world-asia-india-43581122

## Research question

How do different concentrations of NaCl ( 0, 0.05, 0.10, 0.15, 0.20, 0.25 mol dm^-3) affect the growth of Phaseolus vulgaris seedlings by measuring shoot length, number of leaves, leaf surface area, and mass of plants grown in pots?

## Hypothesis

The Shoot Length, Number of leaves, Surface area of the leaves, wet mass of the leaves and the dry mass of the leaves will decrease as the concentration of the salt solution given to the plants increases.

## Background

Plants tend to vary in their levels of saline tolerance. The review of literature shows that much work has been done in the field of studying the effect of salt on the growth of plants. Salinity tolerance is a complex phenomenon. It results from different physiological interactions. There are many scientific reports indicating a relationship between an increase in salt concentration and decrease in plant length(Rui et al., 2009, Memon et al., 2010). Several researchers have investigated the effect of various levels of NaCl on leaf surface area and indicated that the leaf surface decreases with increase in NaCl concentration(Yilmaz and Kina, 2008, Rui et al., 2009). The Leaf number also reduces when there is an increase in the NaCl levels.(Gama et al., 2007, Ha et al., 2008)

Much research has already been done on the topic of the influence of salinity specifically in leguminous plants. Amira M.S.Abdul Qados(2011) studied the effect of salt stress on plant growth and metabolism in the Bean plant using the pot method. He reported that NaCl was responsible for an increase in the height of the plant at lower and medium levels. However, there was a decrease in the plant height at the highest level. The NaCl had little to no impact on the leaf surface area and the number of leaves at lower concentrations, whereas there was a substantial decrease in the two higher concentrations. Research done on Faba bean plants show that elevated salinity levels can cause a decrease in the growth of plants, the number of internodes and the dry and wet weight of the leaves(Fatma Bulut and Şener Akıncı,2010 ). A study conducted by Mena et al. (2015) on Phaseolus vulgaris reported a decrease in growth in the presence of salt similar to predictions made in this investigation.

## Review of literature

As stated before, The review of literature shows several instances where low concentrations of NaCl promote plant growth instead of inhibiting it, one such study is the study by Abdul Quados, (2010), which studied the effects of 0, 60, 120 and 240 mM. It was observed that the average wet and dry mass of the plants increased when treated with 60 and 120 mM solutions. It was also observed that as the salt concentration of the treatment increased, so did the protein content of the bean. A drop in the levels of carotenoids and both chlorophyll A and B was also recorded. The higher the concentration of the salt treatment, the lower the amount of Chlorophyll A and B and Carotenoids found in the beans. However, contrasting results reveal that all concentrations of salt inhibit the growth. In light of contrasting results,I wanted to confirm the level of salinity that can be tolerated by Phaseolus vulgaris.

## Materials

- The materials required for the experiment will be as follows:
- 30 plastic pots
- 15 kg soil
- Measuring Tape
- 1 digital weighing scale(1g - 5000g)
- 1 measuring cylinder ( 250 ml)

## The Variables

*Independent Variable*

| Independent Variable | The different values taken Purpose |
|---|---|
| Salt concentration | 0.00, 0.05, 0.10, 0.15, 0.20<br>This independent variable and 0.25 mol dm^-3 will allow us to observe the variations in plant growth caused by salinity levels. |

*Dependent Variable*

| Dependent Variables How it is being measured |
|---|
| Shoot Length This parameter can be measured by measuring the length of the plant's shoot using a measuring tape. |
| Number of leaves This can be measured by manually counting the number of leaves on the plants. |
| leaf surface area A rough estimate for this value can be obtained by measuring the leaves' length and width and multiplying it. |
| Wet mass The wet mass of the plants can be measured by uprooting the plants and then using a digital weighing scale to check the samples' weight |
| Dry mass The Dry mass of the plants can be measured by uprooting samples of the plants, cutting off the roots and then packing them in envelopes and dehydrating it for 2 days. Then it can be measured using a very sensitive and precise measuring scale. |

*Control variables*

| Control Variable | The reason for why it is How is it being controlled being controlled |
|---|---|
| Type of Soil | Different types of soil can he same type of soil can have varying textures, be ordered from the mineral salt contents and supplier. The specific type varying levels of water of soil used in this retention which could have experiment is Red soil. An impact on the growth rate of the plants |
| Mass of soil in each pot | The mass soil could impact. The amount of soil added the growth rate of the soil. to each pot can be measured and the same amount of soil can be added to each pot. 450 grams of soil was added to each of the pots. |
| Number of seeds in each Pot | If a different number of The same number of seeds are sown in the pots seeds have to be sown in then the resources of the each of the pots. Five pots need to be distributed seeds were sown in each between each of the of the pots. plants, this could affect the growth rate. |

| | |
|---|---|
| Dimension of the pot | The dimension of the pot Use pots of the same could affect the packing dimensions. Every pot and density of the soil and used experiment the water retention. This has a base radius of 4.5 could also affect the cm and top radius of 7.0 growth rate. cm and a height of 12 cm. |
| Volume of water | The volume of water added, While preparing the salt to each of the pots will also solution, make sure that have an impact on the volume of solution growth of the plants added to every pot is the same. 100 ml of solution was added to each pot in this experiment. |

## Safety and risk assessment

- Gloves were worn while handling the soil.
- Every pot and row was labeled in order to avoid any confusion.
- This experiment does not have any ethical concerns.
- The experiment was set up and conducted in my house Balcony due to the COVID Pandemic health safety regulations.
- The plant matter was biodegradable, so it could be safely disposed of.

## Method

Homogenous, healthy Phaseolus vulgaris seeds were obtained. 5 seeds were sown in each plastic. All the plastic pots had the same dimensions. They have a top radius of 7 cm, a bottom radius of 4.5 cm and a height of 12 cm. The big rocks and lumps were removed from the garden soil and each of the pots was filled with 450 grams of soil. The seeds were sown roughly 5 cm deep. Five replicates were set up for each of the treatments and the control group.

Five different sodium concentrations( 0.05, 0.10, 0.15, 0.20 and 0.25 mol dm^-3) were used in the treatments and a control group was also set up. Similar ranges of NaCl concentration were used by the researchers in their studies (Amira M.S.Abdul Qados, 2011) (Fatma Bulut and Şener Akıncı,2010). The pots were irrigated every day with tap water for the first week. After that, the homogenous plants were divided into 6 groups and arranged in lines with each line consisting of five replicates. After the initial one week growth period, the plants were irrigated with 100 ml of sodium chloride solution,

every day for 12 more days. This experiment spanned across a total of 19 days ( including the initial 7 day growth period). The growth measurements for the plants were first taken after the one week initial growth period, and once every three days after that day. These growth measurements include the number of leaves, leaf surface area and shoot length. The Wet mass of the plants was recorded on the final day of the experiment. After that the plant samples were kept in an oven for 48 hours for drying. Then the dry mass of the plant samples were also recorded and measured.

## Experimental Setup

***Figure 2**: Image of the experimental setup showing the five replicates for the 0.05, 0.10, 0.15, 0.20 and 0.25 mol dm^-3.*

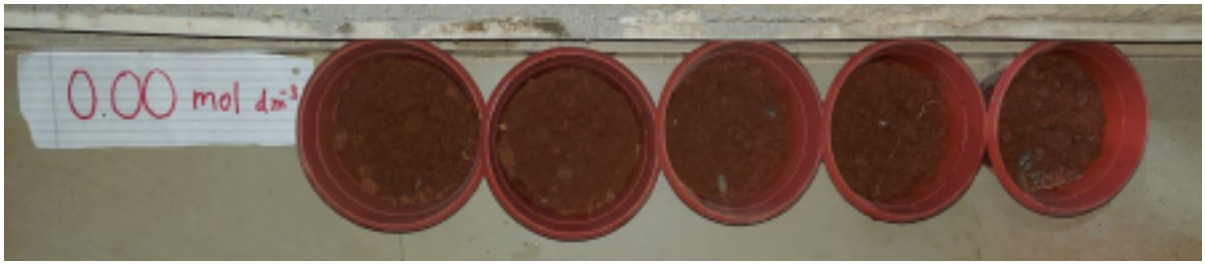



***Figure 3**: Image of the experimental setup showing the control group and the five replicates.*

## Raw Data

Table 1: Raw data for growth shoot length of plant(cm) for 0.00 mol dm^-3 NaCl

| Day | Length of shoot (± 1.00 cm) | | |
|---|---|---|---|
| | T1 | T2 | T3 T4 T5 |
| 7 | 30.00 | 33.00 | 30.00 32.00 34.00 |
| 10 | 35.00 | 37.00 | 34.00 34.00 35.00 |
| 13 | 39.00 | 44.00 | 43.00 43.00 44.00 |
| 16 | 46.00 | 47.00 | 49.00 46.00 45.00 |

| | | | |
|---|---|---|---|
| 19 | 47.00 | 48.00 | 49.00 48.00 46.00 |

*T1 = Trial 1, T2 = Trial 2, T3 = Trial 3, T4 = Trial 4, T5 = Trial 5

Table 2: Raw data for number of leaves for 0.00 mol dm^-3 NaCl

| Day | Number of leaves (± 1.00) | | |
|---|---|---|---|
| | T1 | T2 | T3 T4 T5 |
| 7 | 2.00 | 2.00 | 2.00 2.00 2.00 |
| 10 | 2.00 | 2.00 | 2.00 2.00 2.00 |
| 13 | 5.00 | 5.00 | 4.00 5.00 3.00 |
| 16 | 5.00 | 5.00 | 5.00 5.00 3.00 |
| 19 | 7.00 | 5.00 | 5.00 6.00 5.00 |

Table 3: Raw data for increase of Leaf surface area for 0.00 mol dm^-3 NaCl

| Day | Leaf Surface Area(±1.00 cm^2) | | |
|---|---|---|---|
| | T1 | T2 | T3 T4 T5 |
| 10 | 33.80 | 27.04 | 24.24 24.00 26.23 |
| 13 | 34.12 | 28.91 | 26.67 26.88 28.91 |
| 16 | 35.00 | 29.73 | 28.20 27.29 29.08 |
| 19 | 35.89 | 31.02 | 28.80 28.39 30.21 |

Table 4: Raw data for growth shoot length of plant(cm) for 0.05 mol dm^-3 NaCl

| Day | Length of shoot (± 1.00 cm) | | |
|---|---|---|---|
| | T1 | T2 | T3 T4 T5 |
| 7 | 30.00 | 32.00 | 32.00 34.00 33.00 |
| 10 | 33.00 | 34.00 | 33.00 36.00 34.00 |
| 13 | 37.00 | 35.00 | 37.00 40.00 40.00 |
| 16 | 39.00 | 36.00 | 44.00 44.00 42.00 |
| 19 | 42.00 | 38.00 | 46.00 45.00 44.00 |

Table 5: Raw data for number of leaves for 0.05 mol dm^-3 NaCl

| Day | Number of leaves(± 1.00) | | |
|---|---|---|---|
| | T1 | T2 | T3 T4 T5 |
| 7 | 2.00 | 2.00 | 2.00 2.00 2.00 |
| 10 | 2.00 | 2.00 | 2.00 2.00 2.00 |
| 13 | 5.00 | 3.00 | 5.00 4.00 3.00 |
| 16 | 5.00 | 4.00 | 5.00 4.00 3.00 |
| 19 | 6.00 | 6.00 | 5.00 5.00 4.00 |

Table 6: Raw data for increase of Leaf surface area for 0.05 mol dm^-3 NaCl

| Day | Leaf Surface Area (±1.00 cm^2) | | |
|---|---|---|---|
| | T1 | T2 | T3 T4 T5 |
| 10 | 24.80 | 23.40 | 25.20 24.44 20.50 |
| 13 | 27.82 | 24.40 | 27.19 26.23 22.66 |
| 16 | 28.94 | 26.37 | 28.50 28.80 24.40 |
| 19 | 30.08 | 28.32 | 29.73 30.12 26.00 |

Table 7: Raw data for growth shoot length of plant(cm) for 0.10 mol dm^-3 NaCl

| Day | Length of shoot (± 1.00 cm) | | |
|---|---|---|---|
| | T1 | T2 | T3 T4 T5 |
| 7 | 30.00 | 26.00 | 27.00 30.00 30.00 |
| 10 | 32.00 | 29.00 | 31.00 31.00 31.00 |
| 13 | 35.00 | 36.00 | 35.00 32.00 35.00 |
| 16 | 37.00 | 38.00 | 36.00 37.00 37.00 |
| 19 | 37.00 | 39.00 | 37.00 37.00 38.00 |

Table 8: Raw data for number of leaves for 0.10 mol dm^-3

| Day | Number of leaves(± 1.00) | | |
|---|---|---|---|
| | T1 | T2 | T3 T4 T5 |
| 7 | 2.00 | 2.00 | 2.00 2.00 2.00 |
| 10 | 2.00 | 2.00 | 2.00 2.00 2.00 |
| 13 | 5.00 | 5.00 | 5.00 5.00 5.00 |
| 16 | 5.00 | 5.00 | 5.00 5.00 5.00 |
| 19 | 5.00 | 5.00 | 5.00 5.00 5.00 |

Table 9: Raw data for increase of Leaf surface area for 0.10 mol dm^-3

| Day | Leaf Surface Area(±1.00 cm^2) | | |
|---|---|---|---|
| | T1 | T2 | T3 T4 T5 |
| 10 | 21.84 | 27.60 | 26.51 21.32 22.40 |
| 13 | 24.32 | 28.97 | 27.22 23.45 23.53 |
| 16 | 26.34 | 29.81 | 28.98 24.65 24.64 |
| 19 | 27.43 | 30.32 | 30.29 26.03 25.94 |

Table 10: Raw data for growth shoot length of plant(cm) for 0.15 mol dm^-3

| Day | Length of shoot (± 1.00 cm) | | |
|---|---|---|---|
| | T1 | T2 | T3 T4 T5 |
| 7 | 29.00 | 30.00 | 28.00 28.00 30.00 |
| 10 | 32.00 | 31.00 | 29.00 31.00 31.00 |
| 13 | 34.00 | 33.00 | 30.00 33.00 34.00 |
| 16 | 35.00 | 33.00 | 32.00 34.00 35.00 |
| 19 | 36.00 | 34.00 | 33.00 35.00 35.00 |

Table 11: Raw data for number of leaves for 0.15 mol dm^-3 NaCl

| Day | Number of leaves(± 1.00) | | |
|---|---|---|---|
| | T1 | T2 | T3 T4 T5 |
| 7 | 2.00 | 2.00 | 2.00 2.00 2.00 |
| 10 | 2.00 | 3.00 | 2.00 2.00 2.00 |
| 13 | 5.00 | 5.00 | 5.00 5.00 3.00 |
| 16 | 5.00 | 5.00 | 5.00 5.00 3.00 |
| 19 | 5.00 | 5.00 | 5.00 5.00 4.00 |

Table 12: Raw data for increase of Leaf surface area for 0.15 mol dm^-3 NaCl

| Day | Leaf Surface Area(±1.00 cm^2) | | |
|---|---|---|---|
| | T1 | T2 | T3 T4 T5 |
| 10 | 19.60 | 18.40 | 22.95 20.34 23.65 |
| 13 | 22.54 | 21.89 | 23.92 22.04 25.90 |
| 16 | 23.48 | 23.10 | 25.87 23.08 27.36 |
| 19 | 24.93 | 24.03 | 26.38 24.66 29.84 |

Table 13: Raw data for growth shoot length of plant(cm) for 0.20 mol dm^-3 NaCl

| Day | Length of shoot (± 1.00 cm) | | |
|---|---|---|---|
| | T1 | T2 | T3 T4 T5 |
| 7 | 27.00 | 27.00 | 29.00 27.00 27.00 |
| 10 | 29.00 | 30.00 | 30.00 29.00 30.00 |
| 13 | 30.00 | 31.00 | 31.00 31.00 33.00 |
| 16 | 32.00 | 33.00 | 32.00 33.00 34.00 |
| 19 | 33.00 | 34.00 | 33.00 33.00 35.00 |

Table 14: Raw data for number of leaves for 0.20 mol dm^-3 NaCl

| Day | Number of leaves(± 1.00) | | |
|---|---|---|---|
| | T1 | T2 | T3 T4 T5 |
| 7 | 2.00 | 2.00 | 2.00 2.00 2.00 |
| 10 | 2.00 | 2.00 | 2.00 2.00 2.00 |
| 13 | 2.00 | 2.00 | 2.00 2.00 3.00 |
| 16 | 3.00 | 5.00 | 2.00 5.00 3.00 |
| 19 | 3.00 | 5.00 | 5.00 5.00 5.00 |

Table 15: Raw data for increase of Leaf surface area for 0.20 mol dm^-3 NaCl

| Day | Leaf Surface Area(±1.00 cm^2) | | |
|---|---|---|---|
| | T1 | T2 | T3 T4 T5 |
| 10 | 22.78 | 23.37 | 17.20 22.89 18.92 |
| 13 | 23.68 | 25.73 | 18.03 25.03 23.01 |
| 16 | 25.74 | 27.64 | 21.16 26.44 24.50 |
| 19 | 27.03 | 28.23 | 21.73 27.45 25.00 |

Table 16: Raw data for growth of plant(cm) for 0.25 mol dm^-3 NaCl

| Day | Length of shoot (± 1.00 cm) | | |
|---|---|---|---|
| | T1 | T2 | T3 T4 T5 |
| 7 | 27.00 | 27.00 | 28.00 31.00 28.00 |
| 10 | 28.00 | 29.00 | 29.00 33.00 29.00 |
| 13 | 31.00 | 29.00 | 30.00 33.00 29.00 |
| 16 | 32.00 | 30.00 | 31.00 34.00 30.00 |
| 19 | 34.00 | 31.00 | 32.00 35.00 31.00 |

Table 17: Raw data for number of leaves for 0.25 mol dm^-3 NaCl

| Day | Number of leaves (± 1.00) | | |
|---|---|---|---|
| | T1 | T2 | T3 T4 T5 |
| 7 | 2.00 | 2.00 | 2.00 2.00 2.00 |
| 10 | 2.00 | 2.00 | 2.00 2.00 2.00 |
| 13 | 3.00 | 2.00 | 2.00 2.00 2.00 |
| 16 | 3.00 | 2.00 | 3.00 3.00 2.00 |
| 19 | 5.00 | 4.00 | 5.00 3.00 3.00 |

Table 18: Raw data for increase of Leaf surface area for 0.25 mol dm^-3 NaCl

| Day | Leaf Surface Area(±1.00 cm^2) | | |
|---|---|---|---|
| | T1 | T2 | T3 T4 T5 |
| 10 | 21.20 | 26.46 | 17.64 20.40 22.36 |
| 13 | 22.08 | 27.65 | 18.00 22.01 24.96 |
| 16 | 23.47 | 28.96 | 19.32 23.83 26.00 |
| 19 | 24.05 | 29.89 | 21.50 24.38 27.72 |

Table 19: Raw data for Final wet mass of the plants

| | Final Wet mass for plants at different saline levels | | | | | |
|---|---|---|---|---|---|---|
| | Concentration of treatment(mol dm^-3) | | | | | |
| | 0.00 | 0.05 | 0.10 | 0.15 | 0.20 | 0.25 |
| Trial | | | | | | |
| 1 | 3.00 | 3.00 | 5.00 | 4.00 | 2.00 | 2.00 |
| 2 | 4.00 | 4.00 | 4.00 | 5.00 | 3.00 | 2.00 |

3 5.00 4.00 3.00 5.00 2.00 2.00 4 4.00 5.00 3.00 3.00 4.00 2.00 5 5.00 5.00 3.00 3.00 3.00 1.00

Table 19: Raw data for Final dry mass of the plants

| | Final dry mass for plants at different saline levels | | | | | |
|---|---|---|---|---|---|---|
| | Concentration of treatment(mol dm^-3) | | | | | |
| | 0.00 | 0.05 | 0.10 | 0.15 | 0.20 | 0.25 |
| Trial | | | | | | |
| 1 | 0.17 | 0.21 | 0.17 | 0.15 | 0.08 | 0.05 |
| 2 | 0.20 | 0.17 | 0.17 | 0.14 | 0.07 | 0.06 |
| 3 | 0.24 | 0.25 | 0.19 | 0.15 | 0.07 | 0.07 |
| 4 | 0.24 | 0.20 | 0.17 | 0.13 | 0.09 | 0.07 |
| 5 | 0.26 | 0.23 | 0.11 | 0.14 | 0.11 | 0.08 |

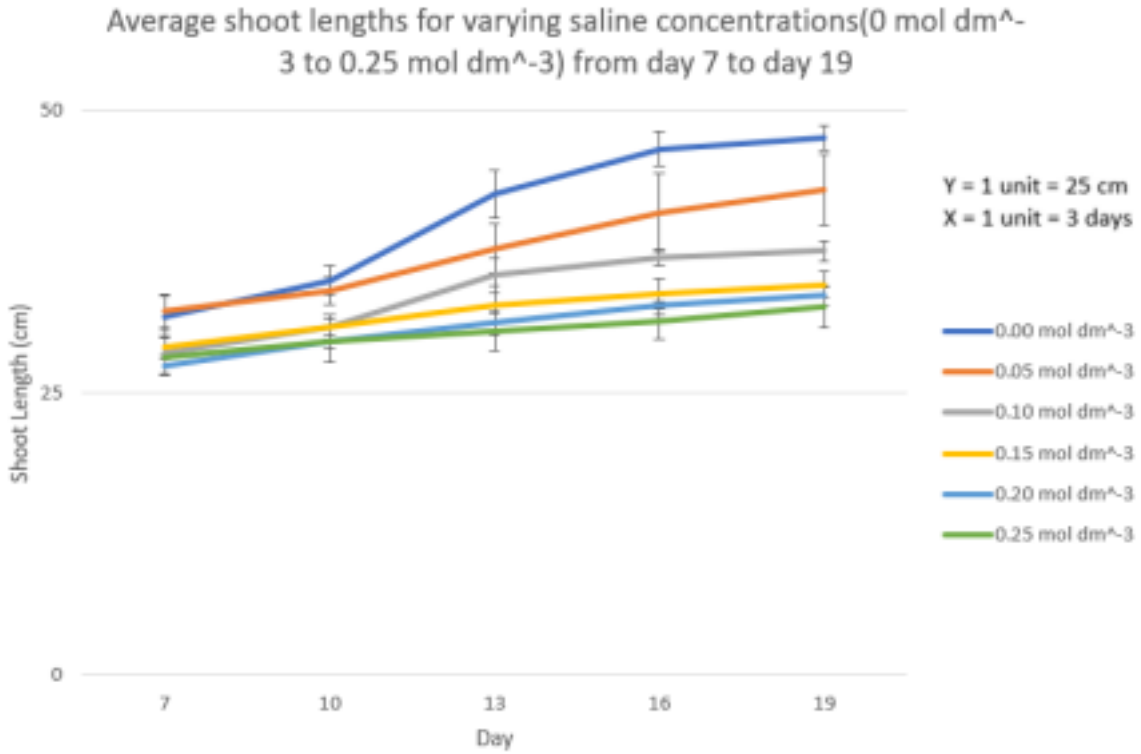
**Processed Data**

Table 19: Average Plant growth(cm) for different salinity levels( mol dm^-3)

| Average Shoot Length (± 1 cm) for different saline levels(0 - 0.25mol dm^-3) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 0.00 | | 0.05 | | 0.10 0.15 0.20 | | 0.25 | |
| Day | L | SD | L | SD | L | SD L SD L SD | L | SD |
| 7 | 31.80 | 1.79 | 32.20 | 1.48 | 28.60 | 1.95 29.00 1.00 27.40 0.89 | 28.20 | 1.64 |
| 10 | 35.00 | 1.22 | 34.00 | 1.22 | 30.80 | 1.10 30.80 1.10 29.60 0.55 | 29.60 | 1.95 |
| 13 | 42.60 | 2.07 | 37.80 | 2.17 | 35.40 | 1.52 32.80 1.64 31.20 1.10 | 30.40 | 1.67 |
| 16 | 46.60 | 1.52 | 41.00 | 3.46 | 37.00 | 0.71 33.80 1.30 32.80 0.84 | 31.40 | 1.67 |
| 19 | 47.60 | 1.14 | 43.00 | 3.16 | 37.60 | 0.89 34.60 1.14 33.60 0.89 | 32.60 | 1.82 |

*SD means standard deviation

L means Length

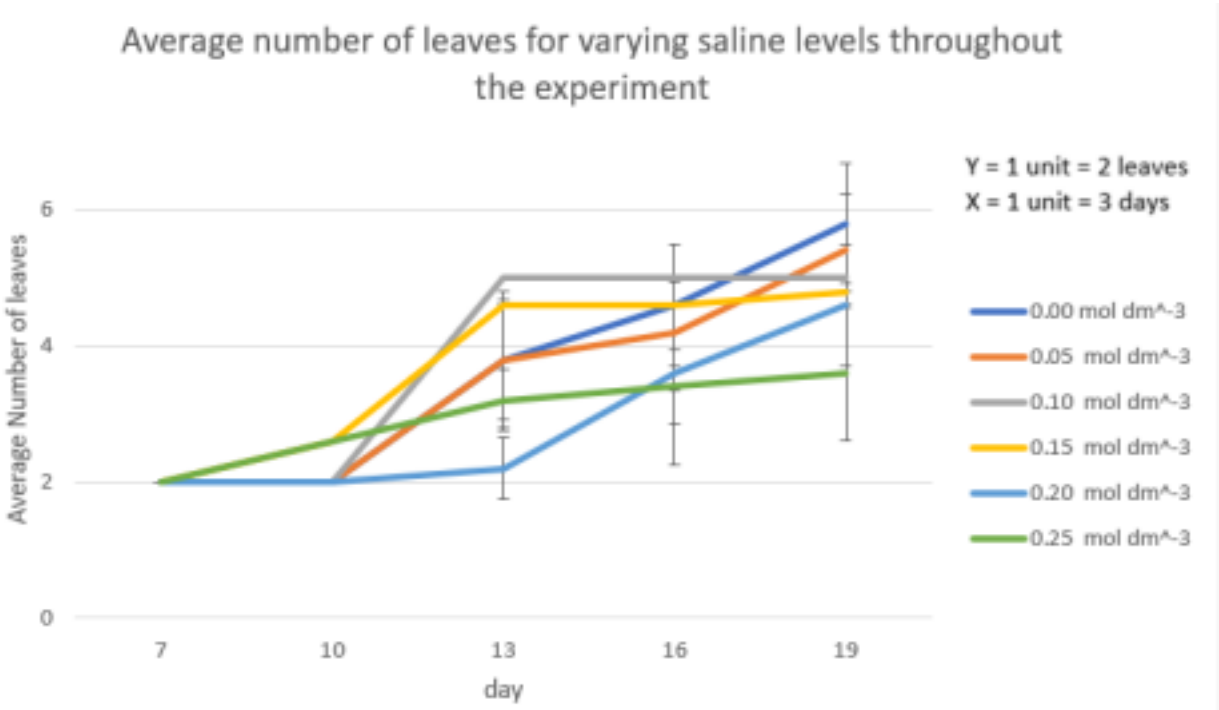



***Graph 1:*** *Average Shoot length(cm) for different salinity levels( mol dm^-3)*

Table 20: Average number of leaves for different salinity levels( mol dm^-3)

| Average number of leaves(± 1) for different saline levels(mol dm^-3) | | | | | | | |
|---|---|---|---|---|---|---|---|
| | 0.00 | | 0.05 | | 0.10 0.15 0.20 | 0.25 | |
| Day | L | SD | L | SD | L SD L SD L SD | L | SD |
| 7 | 2.00 | 0.00 | 2.00 | 0.00 | 2.00 0.00 2.00 0.00 2.00 0.00 | 2.00 | 0.00 |
| 10 | 2.00 | 0.00 | 2.00 | 0.00 | 2.00 0.00 2.60 0.45 2.00 0.00 | 2.60 | 0.00 |
| 13 | 3.80 | 0.89 | 3.80 | 1.00 | 5.00 0.00 4.60 0.89 2.20 0.45 | 3.20 | 0.45 |
| 16 | 4.60 | 0.89 | 4.20 | 0.84 | 5.00 0.00 4.60 0.89 3.60 1.34 | 3.40 | 0.55 |
| 19 | 5.80 | 0.89 | 5.40 | 0.84 | 5.00 0.00 4.80 0.45 4.60 0.89 | 3.60 | 1.00 |

*SD means standard deviation, L means Length

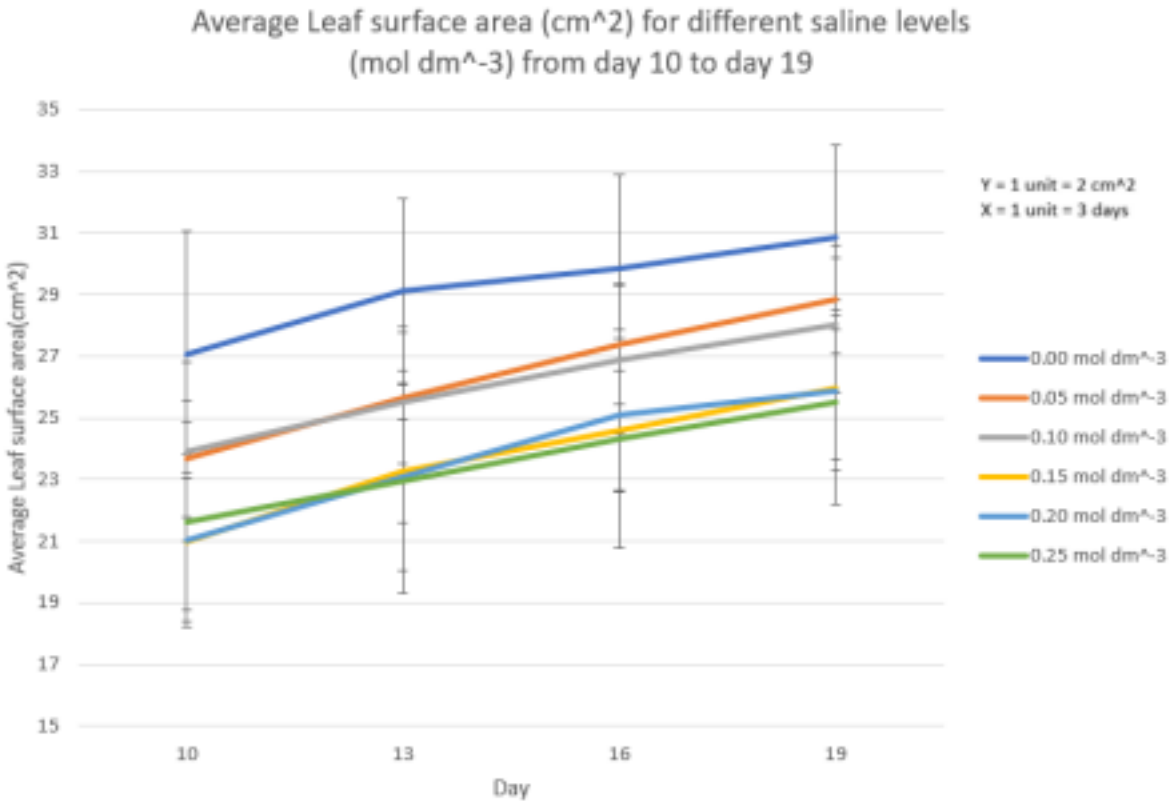



***Graph 2:*** *Average number of leaves for different salinity levels( mol dm^-3)*

Table 21: Average leaf surface area(cm^2) for different salinity levels( mol dm^-3)

| Average Leaf surface area (± 1 cm^2) for different saline levels(mol dm^-3) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 0.00 | | 0.05 | | 0.10 | 0.15 | 0.20 0.25 | | |
| Day | L | SD | L | SD | L SD | L SD | L | SD L | SD |
| 10 | 27.06 | 3.98 | 23.67 | 1.89 | 23.93 2.90 | 20.99 2.23 | 21.03 | 2.79 21.61 | 3.22 |
| 13 | 29.10 | 3.00 | 25.66 | 2.12 | 25.50 2.47 | 23.26 1.68 | 23.10 | 3.03 22.94 | 3.61 |
| 16 | 29.86 | 3.02 | 27.40 | 1.97 | 26.88 2.41 | 24.58 1.94 | 25.10 | 2.48 24.32 | 3.55 |
| 19 | 30.86 | 3.00 | 28.85 | 1.75 | 28.00 2.18 | 25.97 2.33 | 25.89 | 2.61 25.51 | 3.30 |

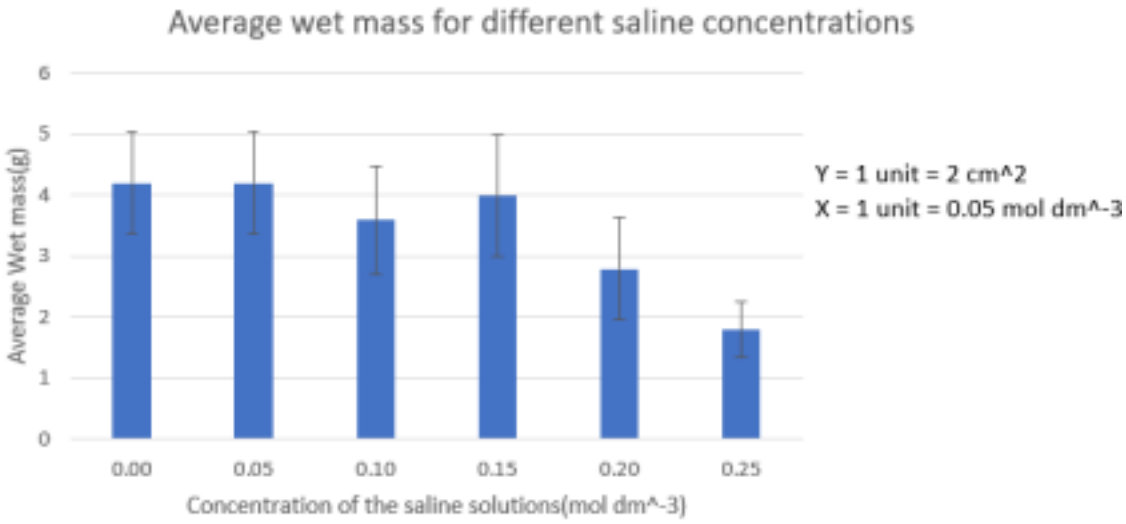
*SD means standard deviation, L means Length




***Graph 3:*** *Average leaf surface area(cm^2) for different salinity levels( mol dm^-3)*

Table 22: Average Wet mass(g) for different salinity levels( mol dm^-3)

| | Average wet mass for plants at different saline levels(± 1 g) | | | | |
|---|---|---|---|---|---|
| | Concentration of treatment (mol dm^-3) | | | | |
| | 0.00 | 0.05 0.10 | 0.15 | 0.20 | 0.25 |
| | | | | | |
| Average final wet mass fo Saline level(g) | 4.20 | 4.20 3.60 | 4.00 | 2.80 | 1.80 |
| Standard Deviation | 0.84 | 0.84 0.89 | 1.00 | 0.84 | 0.45 |

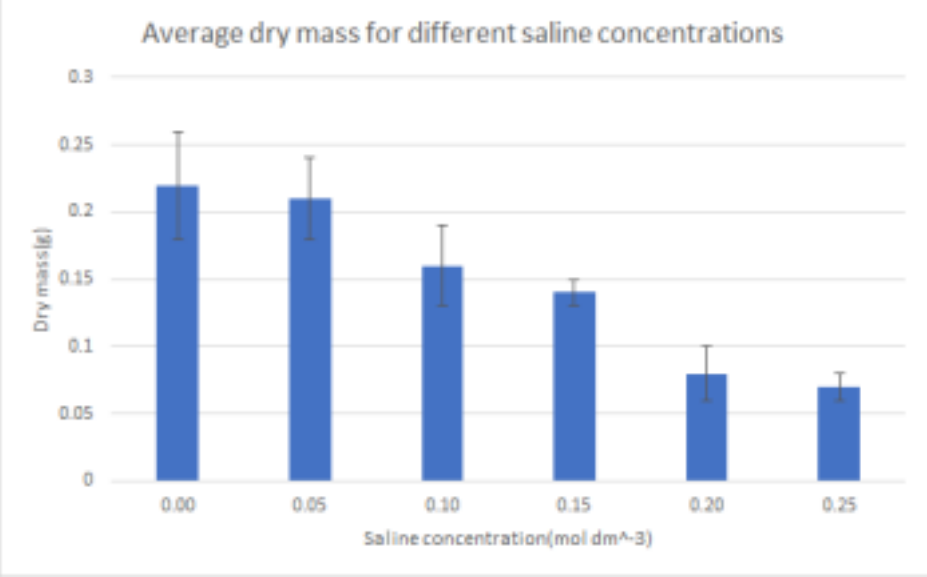



***Graph 4:*** *Average wet mass(g) for different salinity levels( mol dm^-3)*

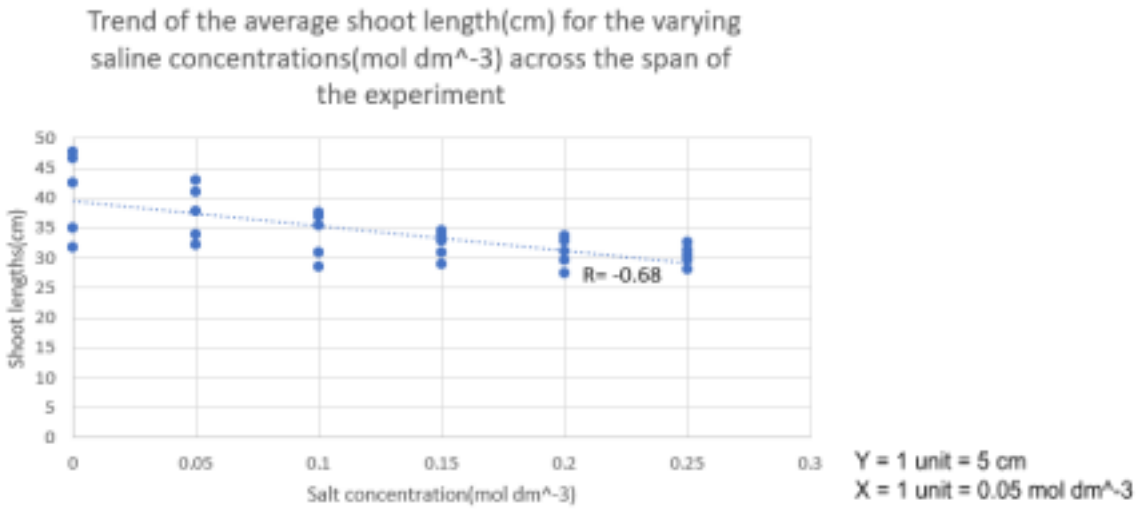
Table 23: Final Dry mass(g) for different salinity levels( mol dm^-3)

| | Final Dry mass for plants at different saline level | | |
|---|---|---|---|
| | 0.00 | 0.05 0.10 0.15 0.20 | 0.25 |
| Average final wet mass for each level(g) | 0.22 | 0.21 0.16 0.14 0.08 | 0.07 |

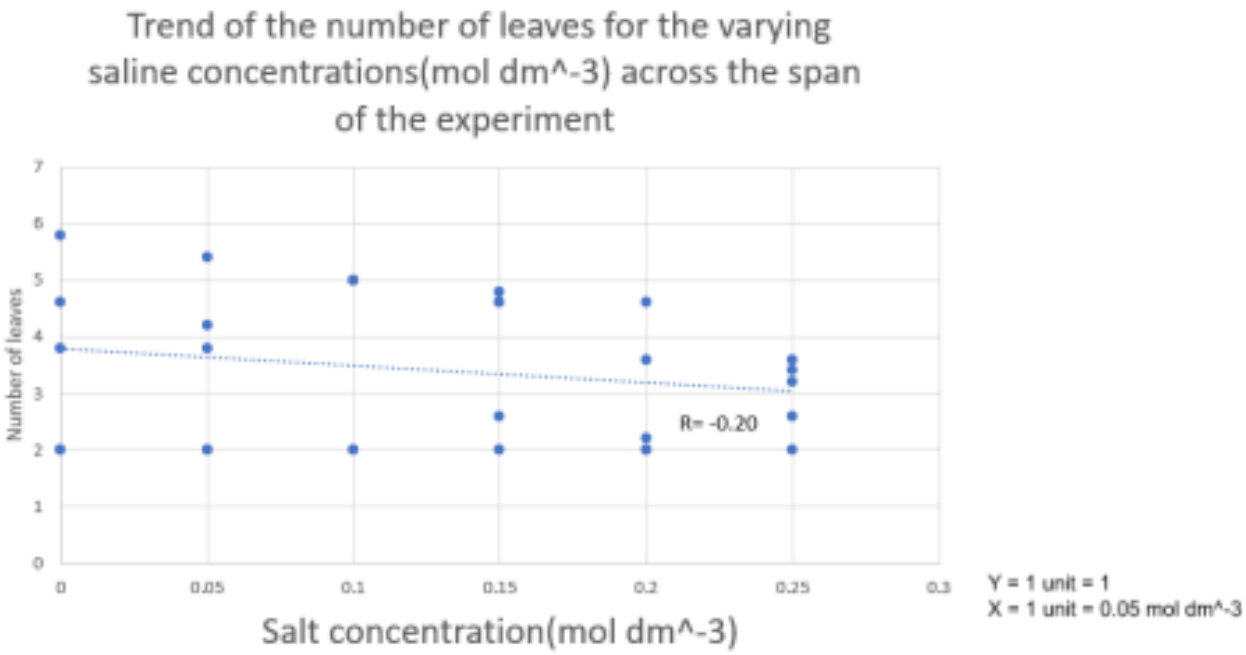
| | | | |
|---|---|---|---|
| Standard Deviation | 0.04 | 0.03 0.03 0.01 0.02 | 0.01 |



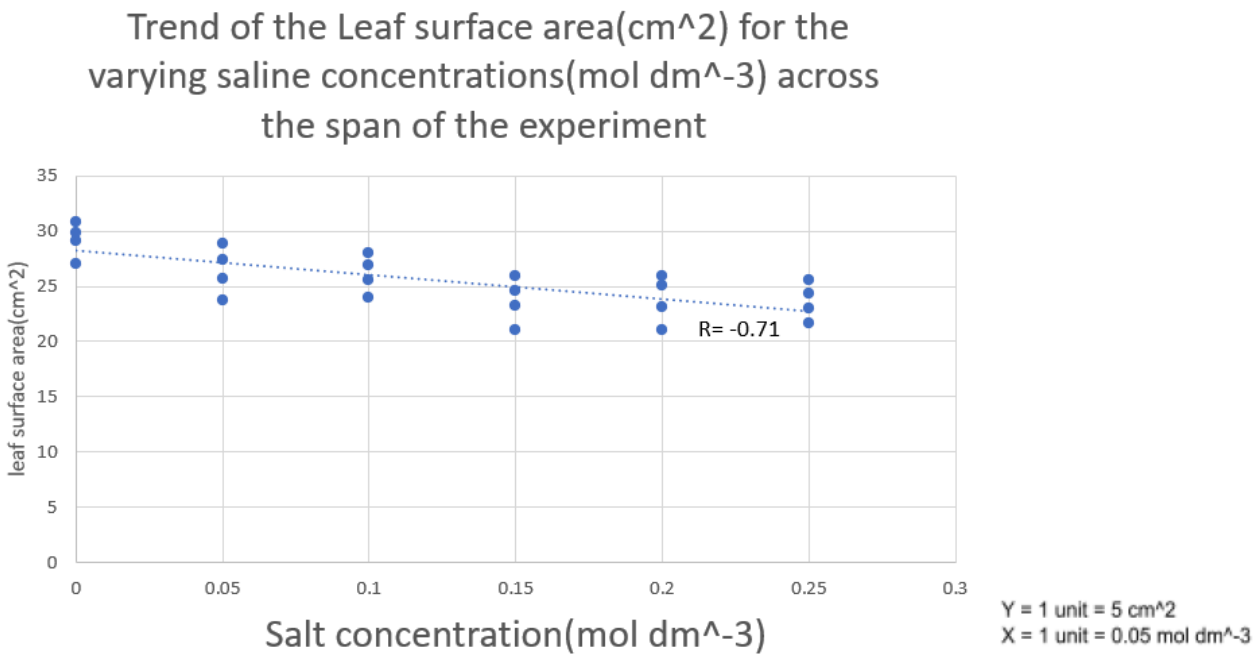

***Graph 5:*** *Average dry mass(g) for different salinity levels( mol dm^-3)*



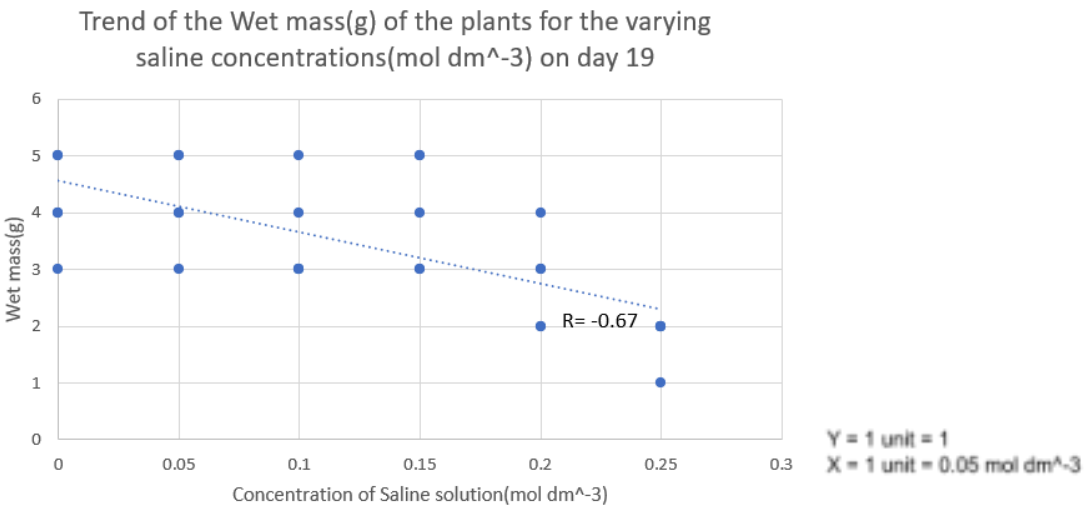

***Graph 6:*** *Relationship between growth in terms of shoot length(cm) and different salinity levels( mol dm^-3)*



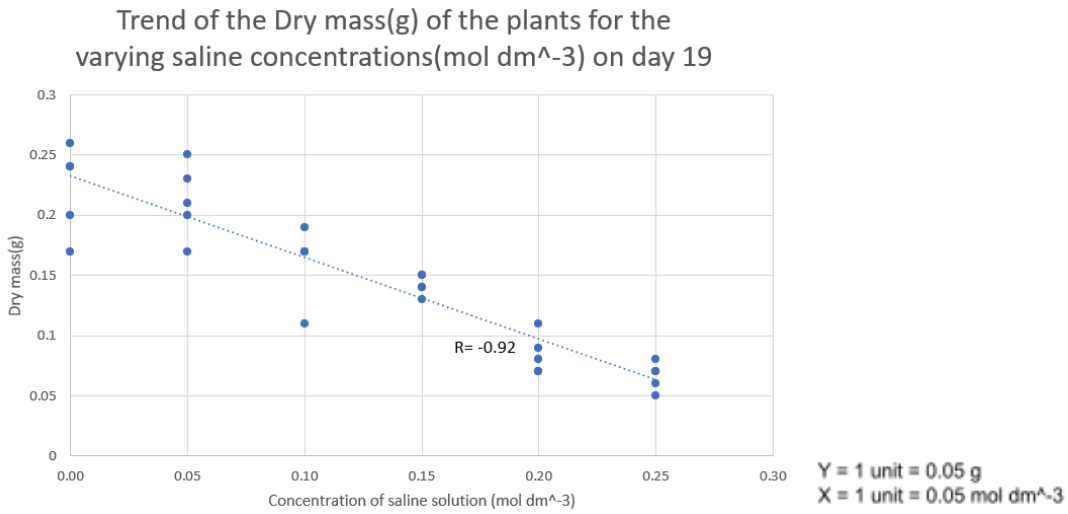

***Graph 7:*** *Trend in the number of leaves for different salinity levels( mol dm^-3)*




***Graph 8:*** *Trend of growth of average leaf surface area(cm^2) for different salinity levels.*




***Graph 9:*** *Trend of growth of wet mass(g) for different salinity levels( mol dm^-3)*




***Graph 10:*** *Trend of growth of dry mass(g) for different salinity levels( mol dm^-3)*

## Sample Calculations

The first type of calculation done in this experiment was averaging, as average values were calculated for every parameter. Here is an example showing the process of calculating the average value for the 0.00 mol dm^-3 NaCl on day 7.

$$average = \frac{30.00+33.00+30.00+32.00+34.00}{5}$$

$$average = \frac{159.00}{5}$$

$$average = 31.80\ cm$$

The next calculation that was done was to find the standard deviation for the average values. The formula for standard deviation is

$$\sigma = \sqrt{\frac{\Sigma(x_i - \mu)^2}{N}}$$

*Where:*
σis the standard deviation value
*xi* is the x values *i*
μ is the population mean
And *N* is the size of the population

The next calculation is the correlation coefficient between salt treatments and growth. The Formula for the correlation coefficient is:

$$r = \frac{n(\Sigma xy) - (\Sigma x)(\Sigma y)}{\sqrt{[n\Sigma x^2 - (\Sigma x)^2][n\Sigma y^2 - (\Sigma y)^2]}}$$

Here is an example calculation showing the process of calculating the correlation coefficient of the average shoot length and the saline treatments.

$$r = \frac{30(119.46) - (1028.8)(3.75)}{\sqrt{[30*36097.04 - (1028.8)^2][30*0.6875 - (3.75)^2]}}$$

$$r = -0.684$$

## Analysis

*Shoot length:*

The shoot length was the greatest for the control(0.00 mol dm^-3) , this is a trend that can be observed throughout the experiment. The plants which were treated with the 0.05 mol dm^-3 NaCl had the longest shoot length followed by plants with higher NaCl concentration( 0.10, 0.15, 0.20 and 0.25 mol dm^-3). In Graph 1 and 6 (Table 19) , it is seen that the growth in terms of plant shoot length is inversely related to increasing saline treatments (0.05-0.25 mol dm^-3). Thus, when the saline concentration increases the average shoot length decreases.

*Number of leaves*

The control(0.00 mol dm^-3) had the most number of leaves on average(5.80) followed by the samples that were given 0.05, 0.10, 0.15, 0.20 mol dm^-3 NaCl(5.40-4.60) treatment. The plants that were treated with the highest NaCl(0.25 mol dm^-3) solution had the lowest number of leaves(3.60) on average. This can be observed in table 20, graph 2 and graph 7. Thus, when saline concentration increases the average number of leaves decreases.

*Surface area:*

The average surface area of the leaves is also highest for control(0.00 mol dm^-3 NaCl) followed by plants that were given the 0.05, 0.10, 0.15 and 0.20 mol dm^-3 salt treatments. The plants subjected to the 0.25 mol dm^-3 salt treatment had the lowest average leaf surface area as compared to the other concentrations throughout the experiment. This is evident from Table no. 21, Graph no. 3 and Graph no. 8.

*Wet mass*

The average wet mass was the highest for the control(0.00 mol dm^-3 NaCl),which was 4.2 g, followed by the plants that received the 0.05, 0.10, 0.15 and 0.20( mol dm^-3 NaCl), which was 4.2 - 2.8g. The plant that received the highest salt treatment(0.25 mol dm^-3 NaCl) had the lowest average wet mass(1.8g) . This trend can be clearly observed in the wet mass in Table 22, Graph 4 and Graph 9.

*Dry mass*

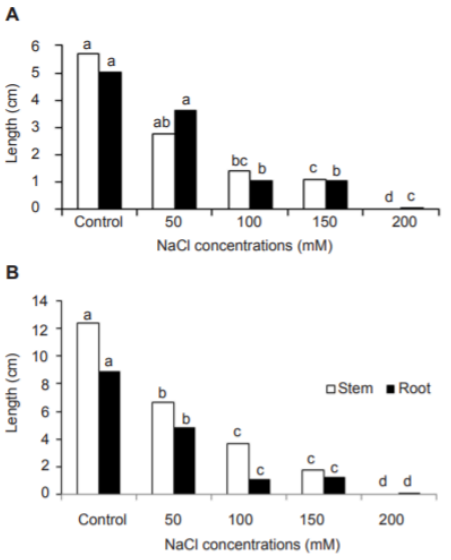
The average dry mass was the highest for the control(0.00 mol dm^-3 NaCl), which was 0.04 g, followed by the plants that received the 0.05, 0.10, 0.15, 0.20 (0.00 mol dm^-3 NaCl) which was 0.03 to 0.02g. The plant that received the highest salt treatment (0.25 mol dm^-3) had the lowest average dry mass, which was 0.01g. These findings are recorded in Table no.23, Graph no.5 and Graph no.10.

## Discussion

*Shoot Length:*

An overall decrease in shoot length was observed as the salt concentration increased (0.00, 0.05, 0.10, 0.15, 0.20, 0.25 mol dm^-3 NaCl) (Graph 1 and 6 , Table 19). The decrease in the shoot length is due to the additional stresses exerted on the plants caused by the presence of salt in the water. There are two types of stress exerted on plants, these are osmotic pressure and ionic stress. Osmotic pressure is caused when the saline concentration of the water outside the plant is higher than the salt concentration of the root cells. This inhibits the rate of water uptake by the plant, the growth of the cells (Munns and Tester, 2008).

Similar results were obtained by Mena et al. (2015).




ICA Pijao after: A) three days, B) six days. For each variable, different letters above columns indicate significant differences among treatments at P<0,05, according to Kruskal Wallis and Mann Whitney tests.

**Figure 1. Effects of different NaCl concentrations on stem length and root length of *Phaseolus vulgaris* cv.**

***Image 4:*** *Results from Mena et al. (2015)*

The graph indicates a decrease in length as the salt concentration increased (the range of salinity treatment studied was similar to our investigation). Contrasting results were found for Vicia faba, where the shoot length increased for lower NaCl concentrations (60 and 120 mM), however at high concentrations (240 mM) the shoot length decreased. In agreement to our findings, many scientific papers reported a decrease in shoot length as the concentration of salt increases in leguminous plants. For example Mathur et al. (2006) on moth bean (Vigna aconitifolia), Taffouo et al. (2009) on cowpea (Vigna unguiculata), and Kapoor and Srivastava, (2010) on (Vigna mungo).

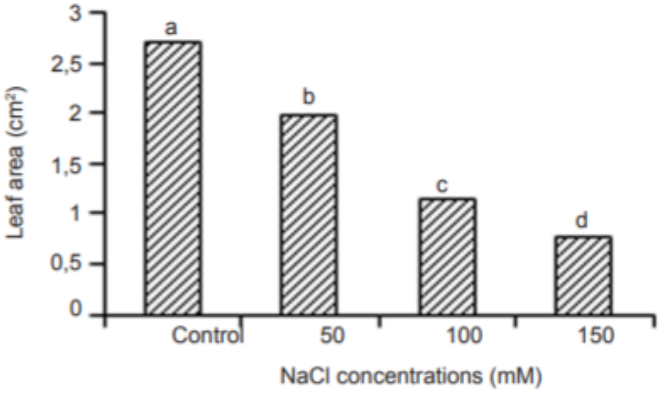
## Number of leaves

When plant growth was observed in terms of number of leaves, there was an overall decrease in the count as the salt concentration increased (0.00, 0.05, 0.10, 0.15, 0.20, 0.25 mol dm^-3 NaCl) (Table no. 20, Graph no.2 and Graph no.7). The reduction in the number of leaves can be attributed to the increased $Na^{+}$ion concentration which causes ionic stress. The ionic stress results in decreased lateral bud formation and reduced growth. Similar results were found by Abdul Quados, (2011) who reported a decrease in leaf number at higher concentrations of 120 mM and 240 mM, however, lower concentrations of 60 mM did not show a significant decrease. Similar results have also been found by Karen et al. (2002), for Cicer arietinum, Raul et al. (2003), for Phaseolus acutifolius , Vigna unguiculata , and Phaseolus filiformis.

## Leaf surface area

When the leaf surface area was measured with respect to increasing salt concentrations (0.00, 0.05, 0.10, 0.15, 0.20, 0.25 mol dm^-3 NaCl), it was observed that the leaf surface area decreased (Table no. 21, Graph no.3 and Graph no.8). This decreased leaf surface area could be explained as a detrimental effect of sodium ions on photosynthesis (Netondo et al., 2004). The reduction in the leaf surface area could be an adaptive mechanism to cope with the loss of water because of the

osmotic stress (Mena et al. 2015). Similar to our investigation, Mena et al. (2015) also studied the effect of salt on Phaseolus vulgaris and their findings corroborate the fact that as the salt concentration increases, the leaf surface area decreases (Image 5).




Different letters above columns indicate significant differences between treatments at P<0,05, according to Kruskal-Wallis and Mann Whitney.

**Figure 2 Effects of different NaCl concentrations on leaf area of *Phaseolus vulgaris* cv. ICA Pijao after six days.**

***Image 5:*** *Results from Mena et al. (2015).*

Abdul Quados, (2010) also reported decreased leaf surface area in Vicia faba when treated with concentrations (60mM to 240mM). Similar results have also been obtained in several different plants.( Jamil et al. 2007, Zhao et al. 2007 and Yilmaz and Kina, 2008) . In this case, decrease in leaf area could be explained by the negative effect of salt on photosynthesis that leads to the reduction of plant growth and leaf growth. The lowered leaf areas per plant indicates adaptive response of P. vulgaris plants for controlling water losses under salinity conditions.

## Wet mass

When the wet mass of the plants treated to the different saline treatments is compared, it is seen that the wet mass of the samples decreased( Table 22, Graph 4 and Graph 9). This can be explained by the ionic stress caused by excess $Na^+$, which leads to decreased photosynthesis and impaired growth of the Lateral buds. A study conducted by Abdul Quados, (2010), on Vicia Faba found contradicting results. In that study it was found that the fresh mass of the plants increased as the salt concentration also increased. They attributed this fresh weight increase to increased size of sap vacuoles to cope with salt stress. However, there are several studies that support our result of decrease in fresh mass. For example studies by Jamil et al. (2007) on Raphanus sativus , Ha et al. (2008) on Kyllinigia peruviana, Rui et al. (2009) on Bruguiera gymnorrhiza , and finally Memon et al. (2010) on Brassica campestris.

## Dry mass

When Dry mass is the parameter being observed with the increase in salt concentration, it can be observed that the dry mass of the samples decreases( Table 23, Graph 5 and Graph 10). This can be explained as a result of the osmotic and ionic stress of NaCl causing reduced growth . Another study done on Vicia Faba refutes our results, as in that study, the dry mass of the samples increased as the salinity increased. However, research conducted by several different researchers on different species corroborates our findings. These include a study by Jamil et al. (2007) on Raphanus sativus , a study

by Ha et al. (2008) on Kyllinigia peruviana, a study by Rui et al. (2009) on Bruguiera gymnorrhiza , and finally a study by Memon et al. (2010) on Brassica campestris.

## Conclusion

This entire experiment began with the research question,' To study the effect of different concentrations of NaCl (0, 0.50, 0.10, 0.15, 0.20, 0.25 mol dm^-3) on the growth of Phaseolus vulgaris seedlings by measuring shoot length, number of leaves, surface area of leaves and change in pots'. And it is fair to say that this experiment was successful at fulfilling the objectives proposed by the research question.

Salinity has an inhibitory effect on the growth of Phaseolus vulgaris and as the salt concentration increased, the shoot length decreased. The correlation coefficient(R=-0.68) clearly indicated an inverse relationship between increasing salt concentration and decreasing shoot length. Similar result was observed in Phaseolus vulgaris by Mena et al. (2015). The leaf number decreased as salt concentration of the treatment increased with a correlation coefficient of -0.20, which is not a very strong indicator of inverse relationship between them. However, R= -0.71 was observed between leaf surface area and salt concentration which indicates a strong inverse correlation between them. Similar results were obtained by Mena et al. (2015) and Abdul Quados, (2010) and many other researchers. The fresh mass also decreased with increasing NaCl concentrations(R=-0.67). The impact of salt was very evident for the dry mass, with a R value of -0.92. Since dry mass is a more reliable measure, we can say that the impact on growth was substantial. In conclusion, it can be stated that the overall growth in Phaseolus vulgaris was impaired in the presence of even low concentrations of salt(Graph no. 1 to 9 and Table no. 19 to 23). In contrast, low concentration of NaCl increased the growth as reported by Abdul Quados, (2010).

Finally, it means that even low saline concentrations can not be used to irrigate Phaseolus vulgaris plants.

## Evaluation

*Hypothesis*

The data obtained in this study supported the hypothesis. The results revealed that all growth parameters including shoot length, wet and dry mass, number of leaves and leaf surface area showed a decrease as the concentration of the saline treatment increased (0.05-0.25 mol dm^-3). The overall decrease in growth was a result of the osmotic and ionic stress caused by the saline treatments.

*Method*

The specific methodology used to conduct this experiment offers its own set of strengths and weaknesses.

strengths : The methodology of the experiment was simple as no specialized equipment was required and therefore it was conducted during the pandemic at home. The method provides a better estimate of growth as pots filled with soil are used, in comparison to any study done in petri plates to estimate growth. In this experiment the pots used had the same dimensions to obtain comparable results. The type of soil used was uniform and this reduced variation. Different saline solutions were used to irrigate the pots, however the volume of solution added to every pot was kept constant to obtain fair results.

*Weaknesses*

More trials could have been conducted, however five trials provided sufficient data to obtain reliable results. The results obtained for growth analysis from the pot method may vary from results obtained from field trials, however large variations may not be seen. Thus, the pot method does provide a reliable estimate of growth parameters under saline stress. Next, the methodology only studies the effect of sodium chloride on the growth of plants, but not any other types of

salts abundantly found in the soil in the different regions of India like himalayan pink salt and rock salt. However, just using Sodium chloride is more relevant specifically to my locality since sodium chloride salt is more common in the coastal regions of India, hence it was not a bad choice either.

### *Apparatus*

The apparatus used in this experiment have a certain set of strengths and weaknesses.

### *Strengths*

All the apparatus can be used and operated from home which is important as this experiment was conducted at home.

### *Weaknesses*

The apparatus like the weighing scale might have a limited degree of accuracy as they are not professional lab grade apparatus. However, the weighing scale used could measure mass from 1 gram to 5000 grams, which provided sufficient accuracy for the experiment.

### *Possible extensions*

A possible extension to this experiment could be that the experiment can be conducted on a field or in farmland to obtain more accurate results. The effects of different types of salt on the growth of plants can also be studied.

### *Further scope of research*

The experiment conducted in this essay only studies the effect that salinity has on the growth of plants, but not how it affects crop yield. A longer study could be conducted to study the effects of salinity levels on crop yields. More studies could also be conducted to compare the effects of salinity on the growth and development of varying species of glycophytic plants to see which ones are more salt tolerant and which are most salt sensitive. Biochemical chemical analysis of salt tolerant varieties could help in explaining the mechanism of salt tolerance. The pattern of sodium ion accumulation in different parts of the plant could also be investigated to explore the mechanisms.

Advanced studies for protein expression could help in identifying key proteins responsible for contributing to the attribute of salt tolerance. This study can also be conducted in a lab setting with more advanced equipment and methodology, in this case hydroponics can be used. Another possible extension to this experiment could be to study the effect of varying salt concentrations on the growth of different plant species, by using different plant species seeds, this would aid in getting a more accurate understanding and conclusion of how sodium chloride concentrations affect plant growth in different species of plants.

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The Lens Journal
*A journal of perspectives for young researchers*

# Impact of LEGO's Corporate Culture on Innovation

***Research question:*** *How does LEGO'S corporate culture influence its consistent growth in the field of innovation?*

*Shambavi Nair*

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**Introduction and background information**

The company LEGO is a Danish toy production company. Originated in Denmark and particularly famous for its colorful plastic interlocking bricks, they've now established themselves as a household name. With its incredibly simple process and no requirement for glue or gum, Lego was the pioneer of feasible, creative toys and have been living up to their name till date.

My research question is "How does Lego's corporate culture influence its consistent growth in the field of innovation?". Being a person who struggles with generating creative ideas, I have always been inspired by innovation. Lego's corporate culture seemed intriguing. Basing a business purely on creative outlooks seems dicey. The fact that LEGO, one of the most reputable brands used solely creativity and innovation; the facets usually deemed to be risky, to fuel their business further and dominate the market intrigued me. Hence this was worthy of research.

Its corporate culture plays an integral role in the performance, being the link between the workforce and the hierarchy. It is essential to gauge how the different stakeholders are influenced and molded by the corporate culture to maximize success. The research will be looking into the different aspects of their culture which enable the employees to continue the growth of LEGO in the field of innovation and engage in thinking differently which propels the company further into prosperity.

**Methodology**

The research conducted will be via secondary research inclusive of company websites, reports and articles. Websites provide insight on the employee's perspective on the experience with the company's corporate culture. Additionally, optimized are old research papers and case studies on the LEGO brand

giving a deeper understanding on its functioning. Other components of the research include verified blogs and interviews. Given the first person perspective, there is an inevitable bias in the information, however the range of sources provide various inputs on the matter at hand.+

## Theoretical Framework

Leadership is analyzed as a tool, considering the different aspects establishing the foundation of it. Additionally, McClelland's theory is optimized to gauge the motivation of the Lego workforce along with the third tool of corporate culture.

Figure 1.1: https://www.statista.com/statistics/292305/lego-group-net-profit/[1]

## The significance of innovation in Lego

Latching itself onto the target market since the 1960's LEGO has entrenched its name as one of the most popular toy brands. Transitioning from wooden toys to plastic blocks and mini-figures was a challenge filled ordeal, they also faced an unprofitable run in the late 70's due to improper market research, and mis-coordination in the creative complex. Considering 2004 hit them with a [2]26% drop in sales, tipping them over the verge of bankruptcy, LEGO has had a fair share of hiccups in the market. Their revival strategy focused on interacting heavily with the customer base in order to generate feedback on a smaller scale before investing further and bringing about fresh collaborative ideas. One of the very reasons LEGO has recovered from such vile backlashes is its prime focus fixed on this kind of open innovation. Open innovation refers to the organization focusing on external sources of ideas and promoting a flexible mindset.

This methodology paid off with the release of LEGO architecture, primarily the New York city skyline which boosted sales by 290 million euros in 2016. The LEGO friends set also popularized the brand amongst the female audience along with increasing sales by 290 million euros again in 2018.

This brand reigned the market with working on the most simple and practical ideas which hadn't been put to use yet. The reason the Lego bricks caught on so early is due to the low skill level required, and its ability to form and deform easily This made it different from the usual construction kits sold. This USP enabled it to bring about the imagination across age groups globally and appeal to the various different areas of exploration such as research, psychological practices, therapy etc. LEGO has been able to contribute with new inventions due to its flexible and adaptable cultural quotient which boosts

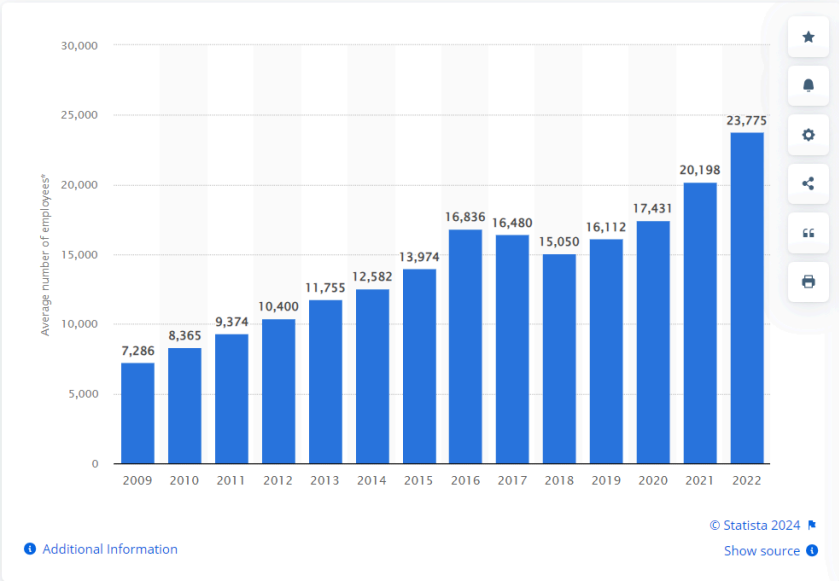
[1] Figure 1.1: https://www.statista.com/statistics/292305/lego-group-net-profit/

[2] https://www.lego.com/cdn/cs/aboutus/assets/blt07abb4b8a3da3f39/Annual_Report_2004_ENG.pdf

creative [3] thinking and enables employees to explore their potential fully. This is achieved by one facet of their corporate culture; organized workforce planning.

## Lego's workforce planning

LEGO looks for the streaks of curiosity, creativity and an outgoing personality in their potential employees. The process of work is based on these 3 aspects which branch out to cover a range of other criteria a LEGO employee has to fit. Having an unquenchable thirst for exploration fuels their risk-taking ability in the employee. This is crucial in order to conduct experimentation as far as product plans are concerned which eventually leads to successful ideas. As stated by Thomas Moller Jeppesen, the HR director of the Lego group in Denmark; "Curiosity, play and experimentation are key to our culture when it comes to innovation and trying new and different things, and that is part of that uniqueness in the LEGO Group." [4]These characteristics are also essential to form an adaptable workforce, one which can be flexible and incorporate change.




[5]***Figure 1.2:*** *https://www.statista.com/statistics/292314/number-of-employees-of-the-lego-group-worldwide/*

With the constant different changes in the industry, creating a team which will withstand the hurdles in the future requires the correct combination of the mentioned caliber. LEGO focuses on those who can offer productivity with a creative outlook, as well have their share of fun and exploration to enhance potential for new innovations, regardless of the change in circumstances. The mission [6]statement "Inspire and develop the builders for tomorrow" is fulfilled by numerous dedicated professionals with unorthodox thinking. With innovation being the key aspect upon which the company establishes itself, the employment process is designed to cater to business-specific needs.

[3] *Open innovation: https://digital.hbs.edu/platform-rctom/submission/everything-is-awesome-product-innovation-at-lego/*
[4] *Jeppesen's quote:https://www.insidehr.com.au/4-ingredients-lego-employee-experience/*
[5] *Fig 1.2: https://www.statista.com/statistics/292314/number-of-employees-of-the-lego-group-worldwide/*
[6] *Mission statement: https://mission-statement.com/lego /*

## The recruitment process

Interviews focus on questions which give prime importance to the employee as an individual, and their adaptability in the company and they take about 2 weeks to form a decision. After analyzing 72 questions, I derived the aspects encountered in the questions asked are-[7]

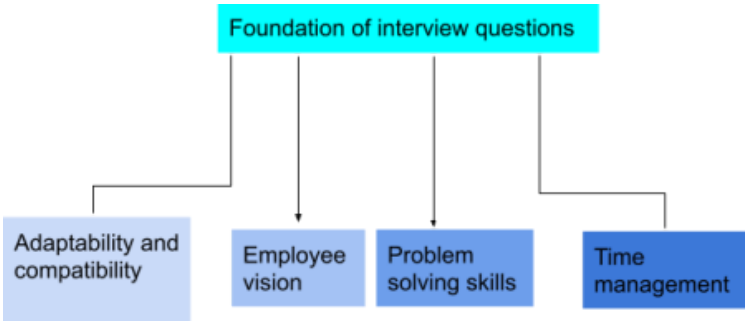



***Figure 1.3***

### Adaptability and compatibility

Lego look at the cultural quotient of the employee. It is essential to make sure the worker's ethic compliments the business. This company is rooted strongly in team-work and people management hence checking their compatibility via putting the employee's personality, attributes and caliber in question is part of the interview. The amount of time they will take to adjust and make significant contributions to the business is also looked upon. This enables the employees to gauge within their capabilities and bring forth flexibility. Innovation can only be achieved when workers have effective communication, for which adaptability and compatibility is necessary.

### Employee vision

Lego centralizes the importance of the employees having a vision for themselves and the company. For innovation to grow at its [8]finest employees have to have targets and direction in their endeavors. Micromanaging is not part of Lego's corporate culture hence gaining knowledge about the potential worker's perspective is essential.

### Problem solving skills

A considerable number of questions are based on tackling work-related conflicts and creative blocks. This gives the company an idea on consistency, stealth and resilience. Lego engages heavily in autonomy hence the workers having adequate knowledge to overcome hurdles is important for product innovation and maintaining regularity.

### [9]Time management

[7] *Time taken to form a decision:* https://www.google.com/search?q=how+long+does+lego+recruitmentprocess+take&ei=ye6uYcXQHJKE4t4Pzvyh4AU&ved=0ahUKEwiF2eaY-ND0AhUSgtgEHU5-CFwQ4dUDCA8&uact=5&oq=how+long+does+lego+recruitmentprocess+take&gs_lcp=Cgdnd3Mtd2l6EAMyCAghEBYQHRAeMggIIRAWEB0QHjIICCEQFhAdEB46BAgAEEM6BAguEEM6BQgAEJECOggILhCxAxCDAToICAAQgAQQsQM6EQguEIAEELEDEIMBEMcBEKMCOgUIABCABDoHCC4QsQMQQzoFCC4QgAQ6BQgAELEDOgQIABANOgcIIRAKEKABOgUIIRCgAToECCEQFToGCCEQDRAVOgQIIRAKSgQIQRgAULEGWIy0GmDOthpoBXACeAKAAfoFiAGbQ5IBDjAuMzYuOC4wLjEuMC4xmAEAoAEBsAEAwAEB&sclient=gws-wiz

[8] *Foundation of interview questions:* https://www.globalguideline.com/interview_questions/Questions.php?sc=LEGO&id=51653

[9] *Beliefs and values:* https://inside.6q.io/company-culture-example-lego/

This in order to get an idea on the work ethic of the employee. Innovation is a qualitative concept, and the prime focus has to be managed carefully to bring in profitable results. Ideas and concepts have to be brought forth to do so. Effective time management gives the employees sufficient time and space to be creative.
Like Lego's workforce planning and recruitment process, much of their culture is established upon the very strong beliefs and value systems. This provides the business with a sense of purpose and direction.

## Beliefs and value systems[10]

Its motive revolves around inspiring and developing children to think creatively, enabling the release of their potential in order to shape their future. Built on the Danish values of hard-work, humility, and teamwork its heritage remains a rudimentary element in their corporate culture despite the massive global recognition gained today. Their core values of creativity, imagination, fun learning, quality care is diligently implemented in their endeavors. Former executive CEO of the company Jorgen Vig Knudstorp suggested that having a strong culture would mean to have an instinctive sense on how to solve problems instead of referring to a generalized rule book/ manual. This perspective along with the openness in the workplace and dedication towards core values influences the company to have a transformational leadership style, which fuels innovation further given its characteristics.

### Leading by innovation for innovation

Transformational leadership causes a change in the employees and social systems. It encourages and inspires the workers to innovate and make changes which will enable the firm to grow and achieve success. San's micromanaging, the people are made to feel trusted and accountable for making important decisions and navigate their way through hurdles.

Lego's aim is to have the employee pursue the best possible performance, and constant supervision barricades that. Being supportive and listening to their ideas and viewpoints increases the opportunities and enhances the outlook towards situations. Interpreting the Danish expression of "managing at eye level" there is open two-way communication and equality when it comes to importance. They intend to exemplify the ethics and moral standards, by having a clear vision of values. This allows feasiblementorship while simultaneously enabling them to take ownership of their choices. Transformational[11] leadership is executed in LEGO by ensuring that the employees follow the **4 pillars of innovation** crafted for the company.

[10] *Leadership style: https://hbr.org/2009/01/lego-ceo-jorgen-vig-knudstorp-on-leading-through-survival-and-growth*
[11] *4 Pillars of innovation: https://inside.6q.io/company-culture-example-lego/*

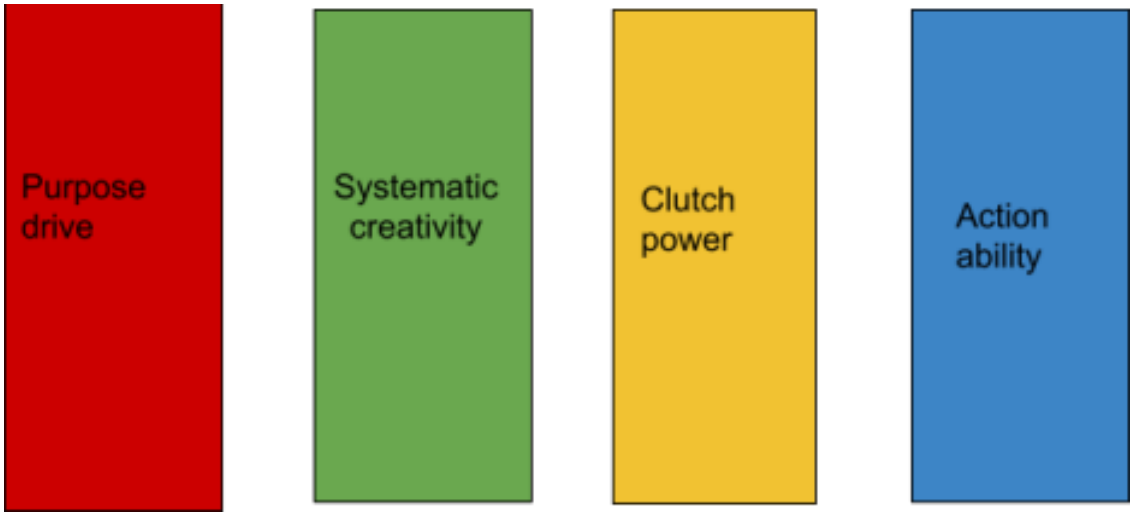



***Figure 1.4:*** *Pillars of innovation*

**1) Purpose drive**

Leaders try to keep the workers informed of their ulterior motives, and give a shared sense of commitment and pride in fulfilling their mission. These include "striving to get your best everyday", "focus on quality" and "taking responsibility for doing the right thing for children, protecting and defending the reputation and ultimate purpose of the brand." Once the employees understand their own role and importance, they can contribute to the essence of the brand with the pinnacle of corporate purpose. Once this is achieved, they engage further in trying to think out of the box and innovate.

**2) Systematic creativity**

Transformational leadership inspires workers to collate past experiences and imagination to find the most appropriate solutions. This includes learning, developing, experimenting and continuous improvement in everyday problem solving. Many decisions and conclusions have been made when employees collaborate by building lego towers together! These unique methodologies enable the employee to have an openness to change, be flexible and have the ability to take on difficult challenges. Striving to unlock creativity, thinking and imagination gives more opportunity for the breakthrough of innovative ideas. The time dependency to come up with fresh outlooks also decreases because of this system.

**3) Clutch power**

This refers to the sense of belonging created amongst the employees because of transformational leadership. Making the workforce feel like part of a big family globally, socializing and active association along with the comfort of being part of a flat hierarchy makes the workplace free. It focuses on building relationships that are able to sustain changes and flexibility. The employees are taught to understand the importance of healthy conflict resolution without creating much tension, the motto being "LEGO before ego". This also shows that LEGO genuinely cares for its workforce beyond their productive contribution for the brand. The legitimate interest in the well-being of the workforce binds them to work harder, and be loyal to the mission and vision of the company.

**4) Action ability**

Refers to the factor of accountability and meeting deadlines. Creativity and innovation is very subjective and hence it can be extremely uncertain to depend on. This element of leadership focuses on employees taking responsibility, delivering promises and being enthusiastic with a "can do" attitude. They're directed to take initiatives, and influence practicality into their work. Transformational leadership does not micromanage, however cannot be perceived to be laid back either.

"Action ability" makes sure LEGO's freedom in the workspace is not abused, while simultaneously giving a recognized platform to build on inventions

However transformational leadership fails to work at times due to multiple reasons. Motivation is assumed to be at peak levels at all times given the enthusiastic approach expected from the employees. It is also extremely risky given the liberty restored in the workforce. Transformational leadership proceeds to be unrealistic at times given the delusional boundaries set. Hence it is important to be in control and implement this leadership style following the 4 pillars

## *The culture's approach on motivation*

The spirit of passion and interest that goes into the products is also a major part of the high-performance culture. Lego, a company about 88 years old, is still winning awards and popularizing amongst the audience, rising to sustain the name of one of the most popular brands. The consistency of the workforce is majorly influenced by the motivation in the corporate culture. Incurring the score of 4.2/ 5 stars for culture on a review based off of the feedback of 415 Lego employees, it is safe to say that the workers are inspired and dedicated to the people culture conducted. To extend the research further Mcleland's theory in order to analyze the methodologies of motivation utilized.

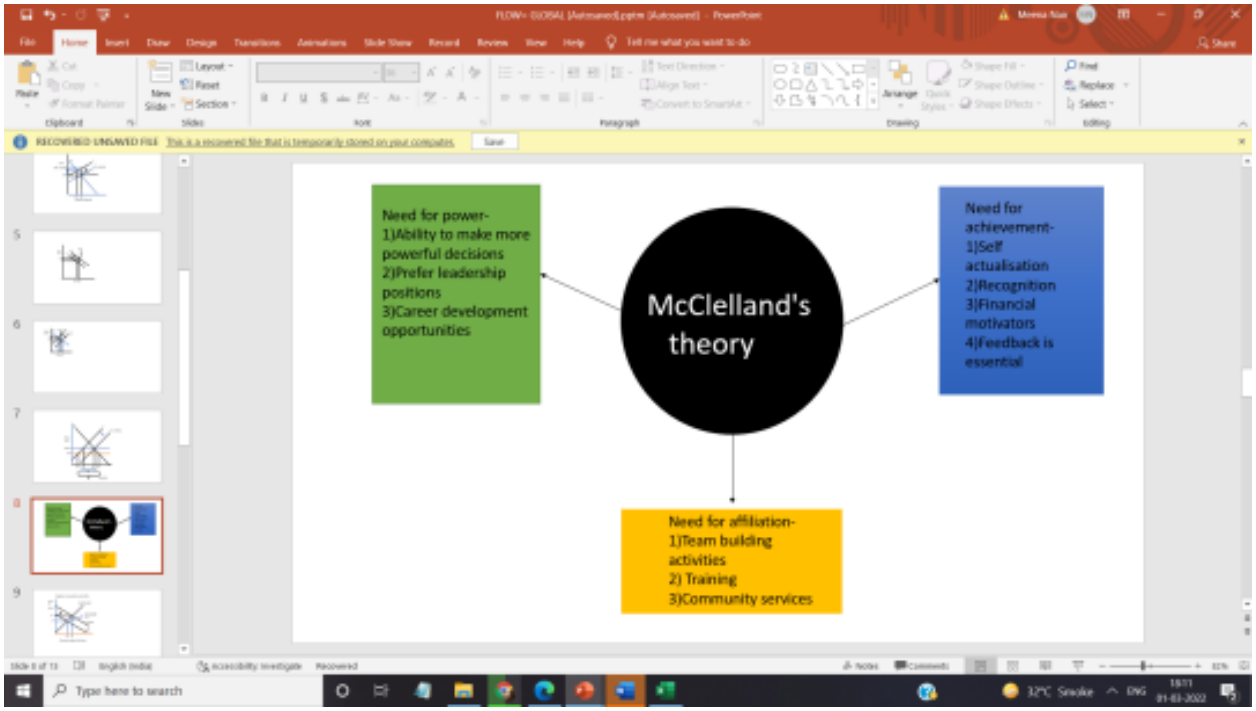



***Figure 1.5:*** *McClelland's Theory*[12]

[13]**Need for achievement:** LEGO employees are trained to be self-motivated and inculcate the drive to work harder and better in order to bring more success to the organization. The employees do not work towards just the benefit of the company, but also gain a sense of satisfaction and earn recognition for their efforts. Constant feedback for employees with this nature is ensured in order to keep the flame of motivation alive with a sense of control and direction.

[12] https://www.lego.com/cdn/cs/aboutus/assets/blt19f572ab26a9af07/Responsibility-Report-2016.pdf
[13] https://www.lego.com/cdn/cs/sustainability/assets/blt123637cf697b8687/1023787_LEGO_Responsible_Business_Principles_130618_FINAL.pdf

**Need for power:** Being a flat hierarchy, there is not much potential for a promotion, transformational leadership anchoring the corporate culture, the employees with a need for power are handled with imposing the ability to make more influential decisions given their caliber. Introducing career development options and opportunities for further horizontal growth given the culture's wide span of control also works. However, it is essential for Lego to give designated positions and have more motivators as far as power is concerned. Currently Lego has scope for improvement in this facet. This will give more credibility to authoritative figures in the business and also increase the inclination workers have towards achieving more influence, directly affecting productivity in a good way. Need for power will also satisfy esteem needs from Maslow's hierarchy hence benefiting the firm for the better.

**Need for affiliation**

There are various team building activities which influence inventions and build employee relations. This satisfies the social needs of the workforce. Collaborative sessions emphasized on leadership dynamics, group communications, cognitive skills, conflict cooperation all involve the building of corporate culture. This gives the employee a sense of belonging and involvement, boosting their morale to work for something greater than intrinsic motives. LEGO also indulges in community outreach [14]programs that enables engagement between the consumers and employees, these include local school visits, events, sustainability workshops as part of the job. Workers can gain qualification to facilitate [15]these events in local communities and bring about development, along with learning new information on the market to give direction to their innovative ideas.

Experience is extremely important to the LEGO group. They strive to create an engaging, empowering atmosphere and make sure that the staff at all levels of the organization know their opinions are valued. This credible validation encourages employees to take more risks and come up with absurd, genius ideas which might be the next breakthrough. Lego ensures to get feedback with an employee survey to know more about employee motivation, satisfaction and the difficulties faced.

Showing genuine concern towards employee feedback creates a better relationship between the company and the workforce. In addition, the concept of LEGO's "people promise" expands the boundaries of the motivation in the corporate further. The "people's promise" is a crucial part of the brand's framework [16]which gives established ground to build the foundation of the strategies and objectives. This prioritizes employees. If they undergo an experience which goes against the people's promise it has to be communicated to the appropriate authority. The role of it is to facilitate execution of business strategies and build the company's long-term health, it is the reason why employees should choose to commit the best, most productive version of themselves for the benefit of LEGO.

Along with the leadership style, motivation and workforce planning, LEGO also initiates inspiration for innovation by creating a lively and inviting environmental design. As stated by Jeppesen, "the key to releasing employee creativity is with the creation of a workplace with a good atmosphere."

**Contribution of the environment's aesthetic towards innovation**

[14] https://www.lego.com/en-sg/sustainability/children/local-community-engagement/
[15] https://sustainablebrands.com/read/product-service-design-innovation/lego-group-investing50m-in-r-d-for-sustainable-materials
[16] People's promise: https://www.insidehr.com.au/4-ingredients-lego-employee-experience/

In the company's HQ, every cubicle has a sculpture that represents the accommodater's personality. [17]LEGO has optimized their own products to create 2 feet tall bright pencil or paper clip holders. There are also table tennis and foosball tables, flat screen televisions with wii game controls, volleyball and basketball courts outside. The various options for recreation break the monotony of work, increased movement increases brain activity, facilitating a fresh flow of creative ideas.

Motivational quotes are painted across the wall on a lenticular wall installation, created from miniscule 1*1[18]

***Figure 1.6***

They've been constructed with great intelligence, hence when viewed from one direction it spells out the original motto of LEGO's founder Ole kirk Christiansen, stating "only the best is good enough.". However, when read from the other side it reveals the company's mission statement "inspire and develop the builders of tomorrow." The innovative thought put into this creation sets an example for the workers to view situations with a different outlook. Their pillars, stairs and enormous pieces of furniture are made to look like it's actually constructed by gigantic Lego bricks, with soft installations made out of their very own product. The office is also designed in order to increase the number of collaborative experiences the employees have together. The work zones are flexible, and adapted for certain tasks. A particular designation of a desk or a cabin is not relevant and the concept of the higher authority having different cabins doesn't exist.

LEGO focuses on giving employees the freedom of management and hence follows activity-based working; thus, each area is designed in order to suit the employee's choice of work. Individuals who prefer autonomy and a quiet atmosphere have soundproofed rooms, along with casual spaces for meetings. Presentations take place in a more formally furnitured room, with coffee machines installed it can be an appropriate area for employees to catch up. However, the fluid nature of the working spaces; not having a designated desk can also act as a source of demotivation. Workers may want a permanent,

familiar, personalized space to completely engross themselves to gain inspiration, unable to adapt to the temporary areas. Moving on, the architecture is lively, positive and motivating. With stuff already made of lego in the very workspace, it gives employees a new environment to immerse themselves in and get inspiration from. This helps innovation to flow freely in the workspace.

## Research and Development

Lego has optimized its resourceful culture to bring innovation to its peak by opening up new methods to gain ideas. To keep improving and gain fresh insight, LEGO created a crowd-sourcing platform where its target market could give in

[17]*Environmental aesthetic: https://theteam.co.uk/blog/workplace-design-lego-instructions-to-the-perfect-working-environment/-lego-instructions-to-the-perfect-working-environment/*

[18] *People's promise: https://www.insidehr.com.au/4-ingredients-lego-employee-experience/*

their inputs and ideas about new products. This open innovation has led to significant successes, and their customer central culture has paid off when it comes to consumer relationship and satisfaction. The crowd sourcing platform allows fans to design their own sets, gather [19]support from other fans (10,000 votes is the cut off) and eventually get their designed set produced officially by LEGO as one of their standard lines. Successful examples of this open innovation are -2013, In Back to the Future's DeLorean set; proposed by Masashi Togami and Sakuretsu, sold for $50. [20]Masashi received 1% of Lego's worldwide profits. This [21]401-piece set includes a brick version of the highly modifiedDeLorean seen zipping around in the movie trilogy, and it's full of little details that satisfy Lego enthusiasts.

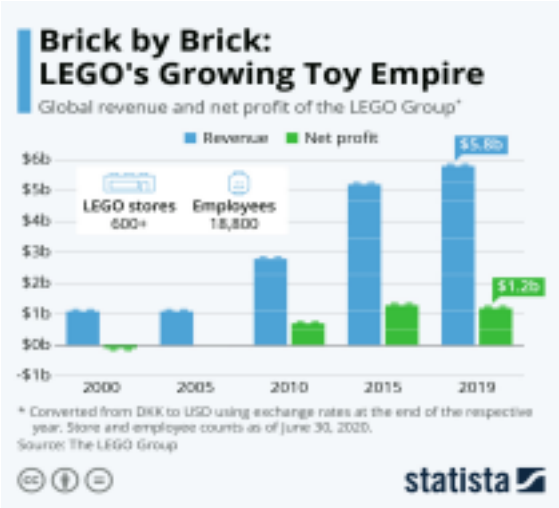



***Figure 1.7***

Another prominent example is the ghostbusters ectomobile which became extremely popular. Launched in 2014, it helped the Lego sales significantly, selling at $199.9. Lego architecture which was launched in 2008 broadens their customer range from just kids to adults, was also pitched by a Chicago architect who believed Lego can be used as potential miniature modeling for bigger projects. Although this was resisted at first, the open-minded Norwegian Lego executive saw promise in the idea and found it worthy to be invested in. The product range has been reviewed favorably by many commentators. All of these inventions were created in the range of 2010-2015, open innovation helped increase the revenues and net profit as the graph suggests.[22]

Over 13000 projects have been submitted via crowdsourcing and the open innovation has enabled Lego [23]to have impressive scores on brand strength index, corporate reputation, familiarity, loyalty, promotion, and huge profits of over $1.34 billion profits in 2015.

## Low risk experimentation culture

Given Lego's flexible culture, experimentation and risk taking is important to the business. Empowering [24]the employees to make decisions has always been an ordeal, however this temperament can always end up being costly. Lego needed to find a cost effective yet empowering balance between innovation and resources hence the Lego future lab was created.

[19] 19 https://chaordix.com/resources/when-community-clicks-lego-ideas-story
[20] https://www.thebrickfan.com/lego-cuusoo-back-to-the-future-delorean-time-machine-achieved/
[21] https://digital.hbs.edu/platform-digit/submission/building-together-how-lego-leverages-crowdsourcing-to-sustain-both-innovation-and-brand-love/
[22] https://crowdsourcingweek.com/blog/lego-success-through-crowdsourcing/
[23] https://www.ideaconnection.com/open-innovation-success/Lego-Success-Built-on-Open-Innovation-00258.html
[24] https://theleadershipnetwork.com/article/lego-sustainable-innovation

Formed in 2012, by merging the new business group [25]and concept lab departments, it is responsible for the innovation agenda of the company.

The lean startup: Lego has adapted this approach to experiment and test their ideas with safety measures, [26]without blowing up the brand. For instance, LEGO universe, an online game that was similar to world of warcraft, was stopped following a year of its launch. Launched in 2012 because a satisfactory revenue model wasn't created. The experiment did not injure Lego's reputation, instead providing various different insights and learnings to establish the company on digital platforms. Another example would be another game Lego launched in 2015, Lego portal racers ; in partnership with Metaio, an augmented [27]reality company. The game uses an Intel RealSense camera and depth technology to allow users to play without their hands, using head movements to steer left or right instead. This remains a learning experience for lego to experiment with different technologies. The lego future lab has enabled employee empowerment by encouraging and exploring new avenues, with a saturated risk level.

The following are the learnings I derived from the Lego future lab-

| | |
|---|---|
| ● | Innovation without direction is risky |
| ● | To experiment and test in safe ways, start with small objects, budget, experiment and prove with learning. |
| ● | Cater to open innovation and take customer feedback[28] |

● The innovation culture should give people freedom to be creative and the direction and focus to deliver productive innovation.

[25] https://www.google.com/search?q=lego+future+lab+formation&oq=lego+future+lab+formation&aqs=chrome..69i57.1717j0j4&sourceid=chrome&ie=UTF-8
[26] https://michaelfearne.com/lego-future-lab-the-rebels-of-innovation-at-lego/
[27] https://www.eurobricks.com/forum/index.php?/forums/topic/104513-lego-portal-racers/
[28] https://michaelfearne.com/lego-future-lab-the-rebels-of-innovation-at-lego/

## Conclusion

Lego has injected innovation thoroughly into their corporate culture. Ranging right from its values and beliefs, open innovation is given primary importance for further growth. As analyzed above, this propels them further to achieve success. Lego has utilized the areas of workforce planning, leadership, motivation, environmental aesthetic and research and development to implement innovative ideas and maintain strong culture. The entire atmosphere in which a Lego employee operates has been designed to influence peak, innovative performance.

Given the multiple recreational activities and flexible work patterns the employees are given a fair degree of autonomy. This combined with accountability and responsibility prepares the workers to have a creative outlook within a realistic time frame, boosting their inventive thinking. This essay has the potential to be gauged into considering the unlisted statistics which influence the innovation as well.

Consistency is achieved by continuously inspiring and motivating the workforce, establishing the purpose of the brand beyond intrinsic motives. The culture forms a family within the workspace, molding everyone to contribute towards the vision of the brand, which is consistent growth in the field of innovation.

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The Lens Journal
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# What Are Countries Doing to Combat the Effects of Fossil Fuels?

*Elizabeth Buxo*

**Abstract**
The global imperative to reduce emissions from fossil fuels, driven by the profound impact of climate change, underscores the critical need for sustainable energy solutions. Fossil fuels, comprising coal, natural gas, and oil, contribute to approximately 80% of the world's energy consumption. This reliance has escalated carbon dioxide and greenhouse gas emissions, intensifying global warming and climate change. This study delves into Trinidad and Tobago's challenges and explores potential solutions, emphasizing the urgency of transitioning to renewables. The consequences of inaction are dire, ranging from changes in weather patterns to increased vulnerability of smaller nations to extreme weather events. A comprehensive understanding of these challenges is crucial for the country to navigate the complexities of achieving a greener and sustainable future. China, on the other hand, has emerged as a global leader in renewable energy, investing heavily in international projects and allocating significant funds to support clean energy initiatives. The country's commitment to reducing pollution levels, decreasing fossil fuel usage, and enhancing energy efficiency positions it as a key player in fostering an ecological civilization.

*Keywords: Fossil fuels, Climate change, Sustainability, Greenhouse gases, Renewable energy.*

## I. Introduction and background information

Reducing emissions from fossil fuels has become a global priority. Fossil fuels are energy sources found in the earth's crust, such as coal, natural gas, and oil. They contain carbon and hydrogen, which can be burned for energy. "Fossil fuels supply about 80% of the world's energy." (Christina Nunez 2019, April 2) We use fossil fuels for electricity, heating, and transportation, by using these we have released carbon dioxide and other greenhouse gases which have trapped heat into the atmosphere contributing to global warming and climate change (Christina Nunez 2019, April 2) “The use of fossil fuels has already increased our average global temperature by 1C if our temperature is above 1.5°C.” We risk further sea-level rise, extreme weather, biodiversity loss, species extinction, food scarcity, worsening health and poverty for millions worldwide. (November 2021 Client Earth) With this in mind, the question arises: what are countries doing to combat the effects of fossil fuels?  In this study, I plan to focus mainly on Trinidad and Tobago with comparisons to China. My initial aim and motivation for this exploration is to understand and identify the local progress made in my country.

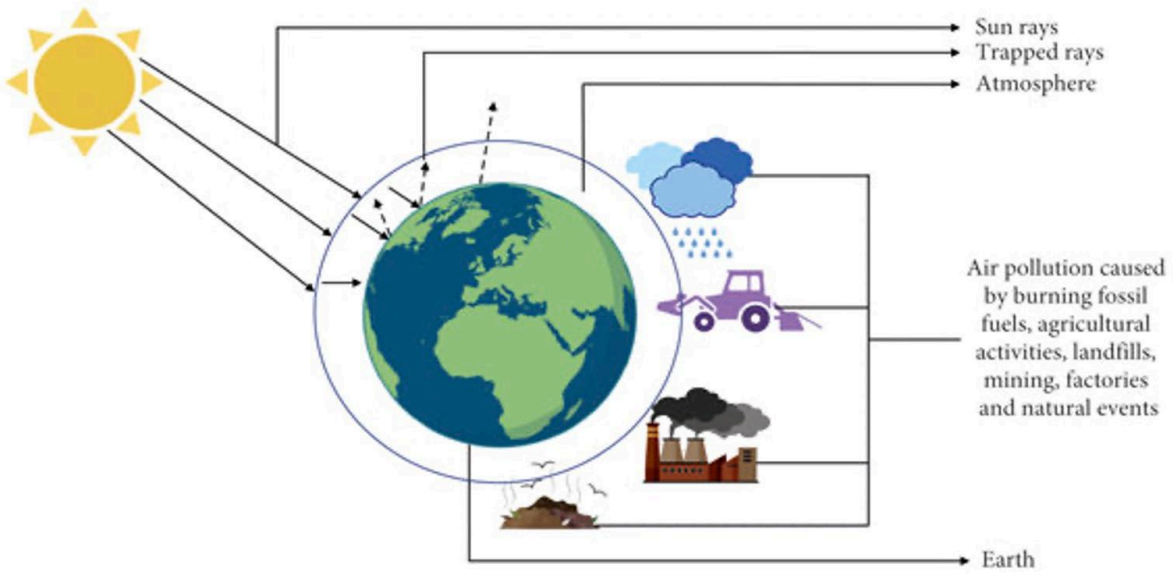


***Figure 1:*** *The Effect of Fossil Fuels on the Earth*

## 2. China and Trinidad and Tobago's relationship with fossil fuels

### *2.1 China's relationship with fossil fuels*

Fossil fuel usage is a global crisis and affects all countries. China's energy needs have expanded as a result of prioritizing economic growth. Its large manufacturing-based economy has made its industrial sector the world's largest consumer of coal, surpassing the rest of the world combined. As a result, China is now the world's largest consumer of energy, the largest producer and consumer of coal and the largest emitter of carbon dioxide. (2021 Center for strategic and international studies)

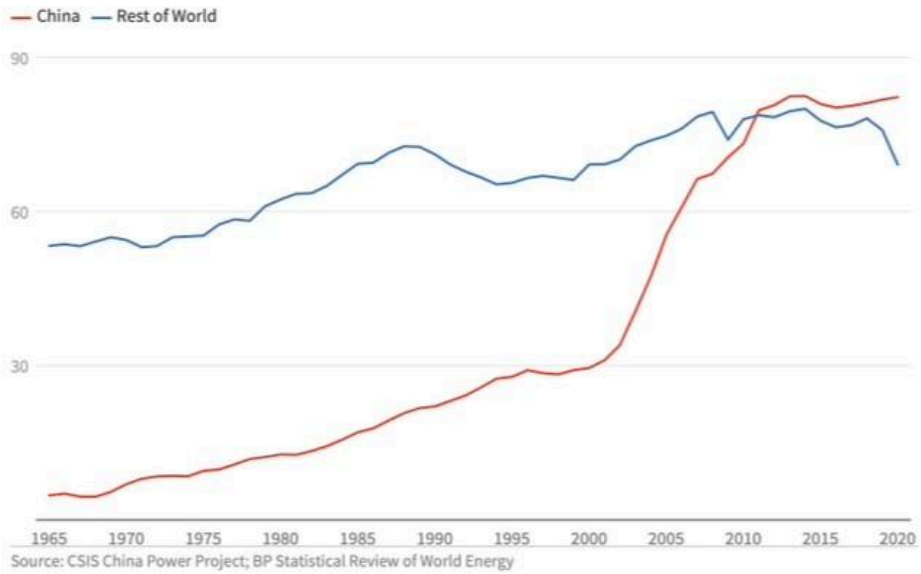


***Figure 2:*** *Global Coal Consumption*

*2.2 Trinidad and Tobago's relationship with fossil fuels*

Trinidad and Tobago, a Caribbean Island located in the Caribbean Sea, heavily relies on fossil fuels for electricity generation (Martin Vogt 2019). The country has an abundant domestic fossil fuel resource, making it the world's largest exporter of both ammonia and methanol and the seventh-largest liquefied natural gas exporter (2015 energy transition imitative). However, this high dependence on oil and gas has led the country to rank comparatively high in global greenhouse gas emissions (Oxford Business Group 2021). Interestingly, Trinidad and Tobago stand out as the only Caribbean economy not entirely dependent on diesel fuel or natural gas.

## 3. Trinidad and Tobago's failed attempt to move towards renewables

*3.1.1 Trinidad and Tobago's past attempt to move towards renewables*

At a budget debate on October 5th, 2015, the minister of finance stated that renewable energy is high on the agenda. "Trinidad and Tobago set an ambitious target in 2015 to generate 150MW of renewable power by 2021, with approximately 150GW currently in use." Additionally, "Colm Imbert, the minister of finance, outlined further objectives in the October 2015 budget speech, aiming for the country to generate at least 10% of its electricity from renewable sources by 2021 (Oxford Business Group 2021).

*3.1.2 Trinidad and Tobago's latest commitment towards renewables*

However, Trinidad and Tobago have fallen short of meeting its renewable energy goals. At the Trinidad and Tobago conference in January 2023, industry and senior government leaders all said "that while we were on the right pathways to secure the future of the sector we simply needed to be moving faster." (Dr. Thackwray 'Dax' Driver 2023) It is concerning that, despite Minister Young's commitment, the renewable energy project has not progressed seven months later (Dr. Thackwray 'Dax' Driver 2023).

*3.1.3 The potential resources that can be used in Trinidad and Tobago*

Leveraging the abundant sun and wind resources in the Caribbean could pave the way for a more sustainable energy future and reduce dependency on fossil fuels and imports. The Caribbean is an excellent resource for solar energy, with about "217 days (about 7 months) of sunshine a year, enabling solar PV plants to generate electricity at a similar or even less expensive cost than conventional power plants do" (Martin Vogt 2019). Including hybrid systems and battery storage offers a promising avenue for addressing both cost and reliability concerns (Martin Vogt 2019).

***Figure 3:*** *Renewable Energy Status and Potential*

*3.2 Chins transition towards renewable energy*

In contrast, "China is taking a lead in renewable energy by investing in an increasing number of international projects, such as the BRICS New Development Bank. China has allocated the first round of green loans worth $811 million to fund

clean energy projects for its members" (2021 Center for Strategic and International Studies). "According to the International Energy Agency, China is expected to contribute 36% and 40% of the world's growth in solar and wind energy over the next 5 years. This positions China as a key player in developing an ecological civilization, employing a cross-sectional industrial approach to reduce pollution levels, decrease fossil fuel usage, address climate change, and enhance energy efficiency" (2021 Center for Strategic and International Studies).

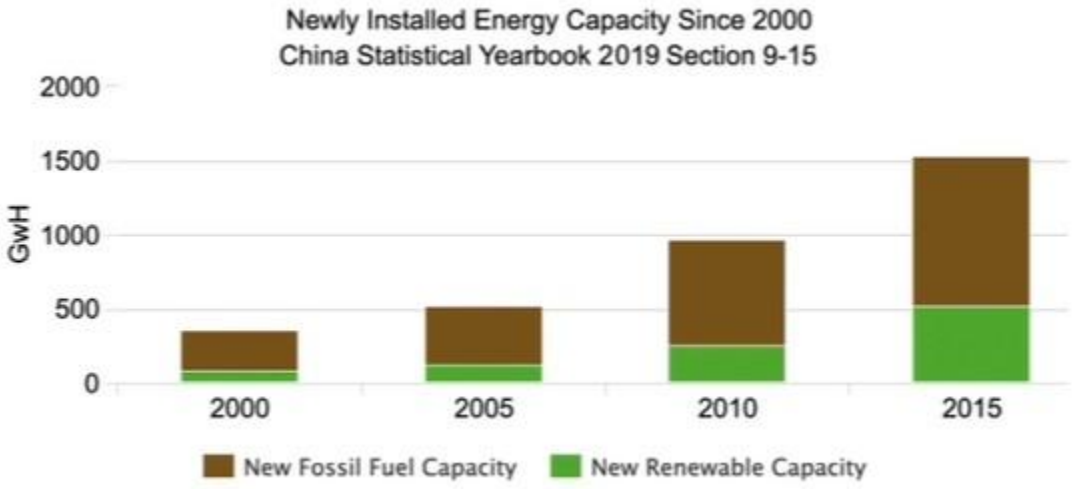


***Figure 4:*** *China's Investment in the Development and Adoption of Clean Energy and Green Technology*

## 4. Issues Trinidad and Tobago need to prioritize

### *4.1.1 Issues Trinidad and Tobago need to prioritize to start moving towards renewables*

Dr. Thackwray 'Dax' Driver highlighted four things he believes the country needs to address to start moving towards renewables: "firstly, fixing the business-as-usual mindset that protects the status quo; secondly, breaking siloed decision-making in the public service; thirdly, ruthlessly streamlining the approvals process; and finally, ensuring that key regulatory agencies can hire the brightest and best, and accessing the skills required" (Dr. Thackwray 'Dax' Driver 2023).

### *4.1.2 The problem and importance of addressing these issues*

The key challenge lies in the lack of awareness and understanding among citizens and leaders regarding the ongoing crisis facing Trinidad and Tobago. Despite the issue being gradual compared to immediate concerns like crime or the pandemic, the decline in natural gas production poses a significant threat to the country's economy. Without securing new investments in green energy production and decarbonization, there is a looming risk of a substantial economic contraction, adversely affecting the standard of living for the entire population. Despite global initiatives toward net zero and declining oil and gas production, the response to the Regulated Industries Commission's electricity rate review shows a reluctance to confront the crisis (Dr. Thackwray 'Dax' Driver 2023).

A significant challenge is the slow and cumbersome approval processes for major projects. A comprehensive review in 2019 revealed that thirty-three major approvals from eight different Ministries or statutory agencies were necessary to progress from a bid round to first gas in upstream gas projects. Most of these approvals occurred sequentially rather than concurrently. Shockingly, in 2023, many decisions still rely on paper files and physical signatures, contributing to delays and, in some cases, crucial files going missing. Streamlining decision-making and approval processes is essential,

especially for attracting substantial investments in renewable energy crucial for realizing green hydrogen plans. Resolving this issue requires meticulous effort, a commitment to streamline processes, and a ruthless elimination of unnecessary steps and decisions that do not enhance the overall approval process (Dr. Thackwray 'Dax' Driver 2023).

## 5. The consequences Trinidad and Tobago faces

### *5.1 The urgency of prioritizing the transition to renewables*

Emphasizing urgency, Dr. Thackwray 'Dax' Driver, states, "We have no time to waste, and collectively Trinidad & Tobago is going to have to find a way to implement changes faster" (Dr. Thackwray 'Dax' Driver 2023). A study done by a scientist from the University of Oxford and Utrecht warns that if governments do not transition from fossil fuels to renewables, we risk passing the point of no return for dealing with global warming. The study suggests that renewables need to increase their total power share by at 2 percent per year. Failing to act now could lead to devasting consequences such as changes in rainy seasons and longer droughts (Martin Vogt 2019). Already, the increasing intensity of hurricanes has started to negatively impact global economies, particularly smaller countries vulnerable to weather changes. In some cases, this threatens the very existence of the country (Martin Vogt 2019).

## 6. Conclusion

To conclude, Trinidad and Tobago face many challenges in transitioning to renewable energy. Despite ambitious goals, the country fails to make progress. Recognizing the importance and commitment to the shift is indeed crucial for initiating meaningful change. A comprehensive understanding of these reasons is essential for the country's successful transition to a greener future. Despite a long-standing relationship with fossil fuels, China has demonstrated a shift towards renewable energy sources, even with its large manufacturing sector. While not fully immersed in green energy, the country has made significant investments toward a greener future.

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The Lens Journal
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# Reasons for International Concern: The Detrimental Effects of Climate Change and Pollution on the Planet's Coral Reefs

*Rebecca Buxo*

**Abstract**
This research paper delves into the destructive effects of climate change and pollution on coral reefs in the hope of bringing awareness and helping to reverse the damage done. It addresses the question of why coral reefs are essential to living organisms and how one, as an individual can take action to combat the issue at hand. It also aims to highlight the critical need for a coordinated plan of action by shedding light on the detrimental effects, such as coral bleaching and ocean acidification, have on our reefs.

*Keywords: Coral bleaching, ocean acidification, sustainability, global warming.*

## 1. Introduction and Background Information

Throughout this research paper, I will be exploring the topic of loss of biodiversity and the ecosystem. In this matter, I will be further discussing how climate change and pollution are having an adverse effect on the earth's coral reefs. This question is relevant to today's society as the majority of the coral reefs all over the world's water bodies have been reported to be bleached and dying due to the onset of multiple stresses.

If we fail to do anything to prevent this mass threat from causing the extinction of these majestic coral reefs, life on Earth as we know it, will cease to exist. This is not an exaggeration, as the destruction of these coral reefs, will not only cause an economic catastrophe as it is estimated over one billion people depend on reefs to survive (Carilli,2013), but it will cause one of the world's most biologically biodiverse ecosystem to become extinct.

Coral reefs are home to millions of wildlife around the globe, they are often referred to as the rainforest of the ocean. They are diverse and complex ecosystems formed by the accumulation and growth of coral colonies. Most of the extraordinary reefs found today are said to be between 5000 and 10000 years old. (National Geographic Kids 2022). Though they make up approximately 0.08–0.16% of the world's oceans, coral reefs are home to almost one-third of all known marine species.

## 2. How is Climate change responsible for coral reef decay?

How is climate change affecting the coral in these reefs you might wonder? Worldwide, the burning of fossil fuels is destroying the earth's ozone layer and thus warming the whole planet. This causes the melting of ice and alternately rising sea levels. The earth's bodies of water have been absorbing the majority of the heat, about 90% so far (NOAA Climate 2020). If the oceans weren't absorbing the heat, the average temperature on land would be fifty degrees Celsius. This causes the water to rapidly warm and is what affects the reefs. The first time this was observed was in the 1970s when scientists noticed the corals losing pigment and becoming colourless. They wondered why that occurred and went about doing a series of tests and experiments.

### *2.1 Coral bleaching*

***Figure 1.*** *shows the comparison between healthy coral and 'bleached' coral. (NBC 6 South Florida)*

In the end, the most certain thing causing the corals to become "bleached" was the rise in the water temperature by as little as two degrees, proving their hypothesis correct. The component the corals lose when this happens is the expulsion of symbiotic algae called 'zooxanthellae', which gives them vibrant colour and helps them produce food. Without it, it slows their growth and makes them more vulnerable to disease and eventually death. Bleaching is a stress response from the temperature rise, much like how our bodies have fevers (National Ocean Service, 2021). The first global-scale mass bleaching occurred in 1980, ten years later in 2010 another one ensued. The years in between these mass bleaches continue to rapidly decrease, resulting in coral dying at a much faster rate than they can reproduce

***Figure 2.*** *illustrates how coral bleaching occurs.*
*(National Ocean Service- National Oceanic and Atmospheric Administration NOAA)*

*Example of coral bleaching.*

A famous example of coral bleaching is the Great Barrier Reef, located off the north-eastern coast of Australia, and known for being the largest coral reef in the world. If you were to ask someone born in the year 1970, they would describe the reef as colourful and enormous, unfortunately, our generation will only know stories at this rate as over 50% of the world's coral reefs have died in the last 30 years. It is predicted that 70-90% of the coral globally will vanish in the next two decades according to scientists from the University of Hawaii Manoa. The 'Status of Coral Reefs of the World: 2020' report, estimated that approximately 14 per cent of the earth's coral has died since 2009.

***Figure 3.*** *Illustrates sight where mass bleaching has taken place.*
*(Australian Marine Conservation Society)*

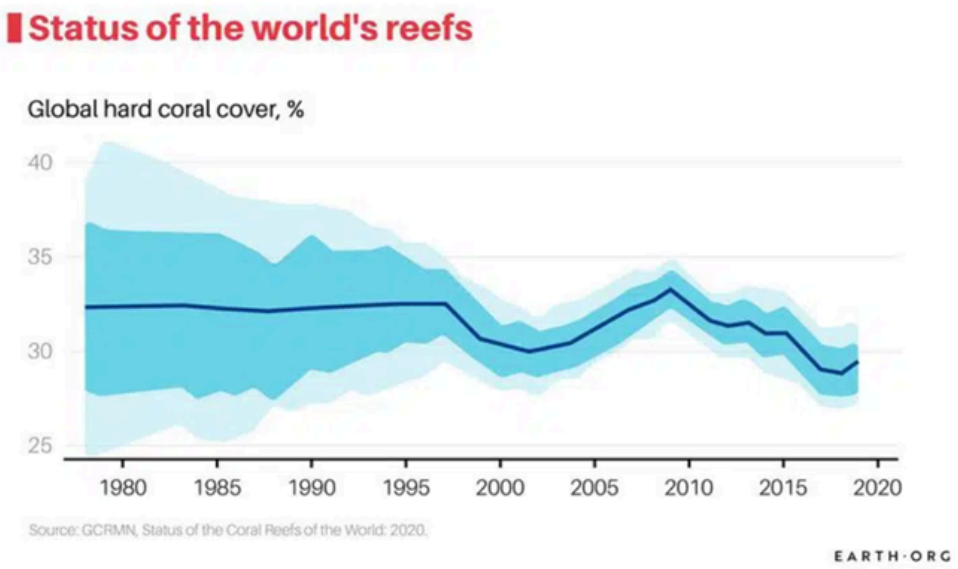


***Figure 4.*** *Shows the decrease in the earth's corals between the years 1980 to 2020.*

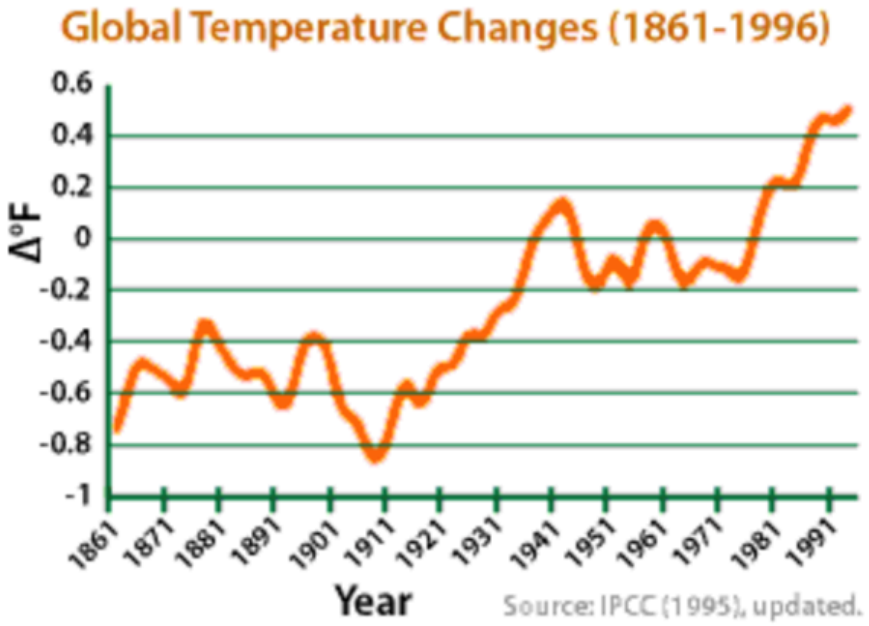


***Figure 5.*** *Shows the increase in global temperatures.*

The earth's temperature is continuously rising, as in 2022 record-breaking heat waves caused temperatures to upsurge to those not experienced since the late 1850's and continuously rise as seen the next year. In 2023, temperatures all around the globe skyrocketed during the summer with the northern hemisphere reaching the hottest it has ever been in history. Unfortunately, this simultaneously caused our oceans to absorb the majority of the intense heat to reach record-high levels.

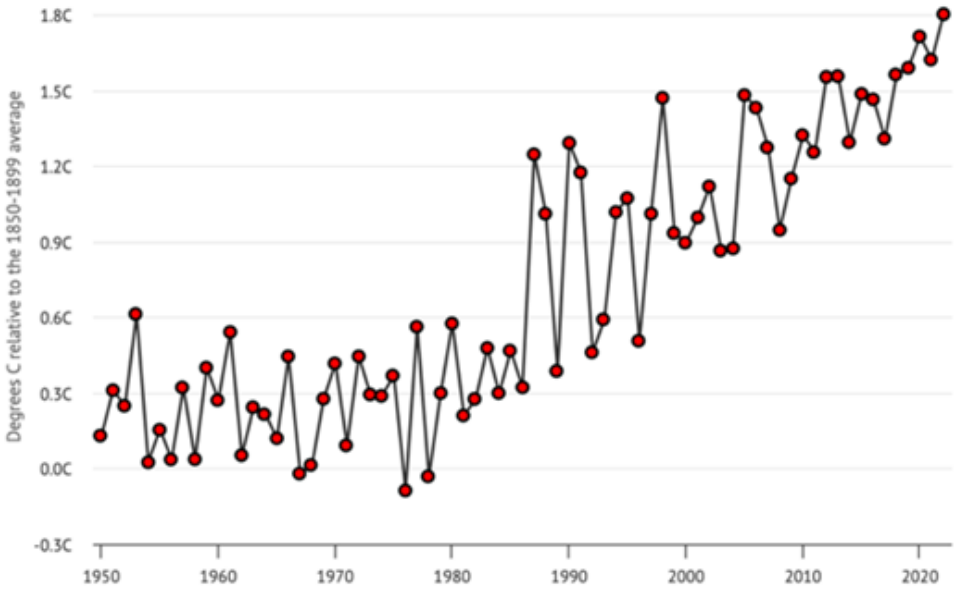


***Figure 6.*** *Showing the rise in land temperatures during summer.*
*(Using Copernicus/ERA data from 1850 & 1950 calculated from the Berkeley Earth dataset)(State of Climate)*

## 3. Why are Coral Reefs Vital?

The reefs contribute greatly to not only the environment but also mankind, they provide food to billions, offer careers, supply natural medicines, and protect the land from natural disasters such as storms and tsunamis (National Ocean Service 2021). The catastrophic massacre occurring in these reefs would have detrimental consequences for both humans and other organisms.

### *3.1 Key justifications why these reefs are essential to human beings.*

#### 3.1.1 Oxygen

One of the most essential aspects of coral reefs for humans is undeniably the oxygen they provide. They are not merely underwater landscapes but a vital source of oxygen. In an interview with Michael Crosby, a marine scientist and president of Mote Laboratory and Aquarium, he asked the interviewer "You like to breathe?" Crosby continues: "Estimates are that up to 80% of the oxygen we are breathing in right now comes from the ocean." This percentage shows how truly important it is to have a healthy ocean and how corals contribute to that.

#### 3.1.2 Occupation and Food Security.

The majority of coastal communities depend on coral reefs as a form of income which is essential to provide for their families. Fish species that use coral reefs as a breeding and feeding ground contribute significantly to global fisheries as approximately half of all federally managed fisheries are only sustained due to coral reefs. The National Marine Fisheries Service estimates that the commercial value of U.S. fisheries from these reefs is over $100 million.

The decline of coral reefs would impact the fish population, leading to reduced catches and compromising food security for millions of people.

3.1.3 Economic impact

The destruction of these coral reefs, will not only cause an economic catastrophe, as it is estimated over one billion people depend on reefs to survive (Carilli,2013) but it is estimated that $30 billion annually are provided by coral reefs through food, fisheries, and tourism. (Hopkins Marine station of Sandford University)

To fully explain how coral reefs will impact the economy we can examine the country of Barbados, a Caribbean Island, located in the Caribbean Sea. The country is known for its beautiful beaches and is a popular tourist attraction mainly for this reason.

The economy is driven predominantly by the revenue of tourism and deprived of it, the island's economy would not survive. The people of Barbados depend financially on the constant flow of tourist cash dollars for their livelihoods.

3.1.4 Costal/Shoreline Protection

Coral reefs act as a natural barrier protecting human life and property, preserving the coastline from erosion and storm surges by damping the rough waves. This is attributed to the physical structure of the reefs which help absorb and disperse the energy of the waves.

They can significantly reduce coastal flooding by dissipating as much as 97% of incident wave energy. Therefore, the loss of these reefs would leave coastal areas vulnerable to the destructive forces of waves and storms.

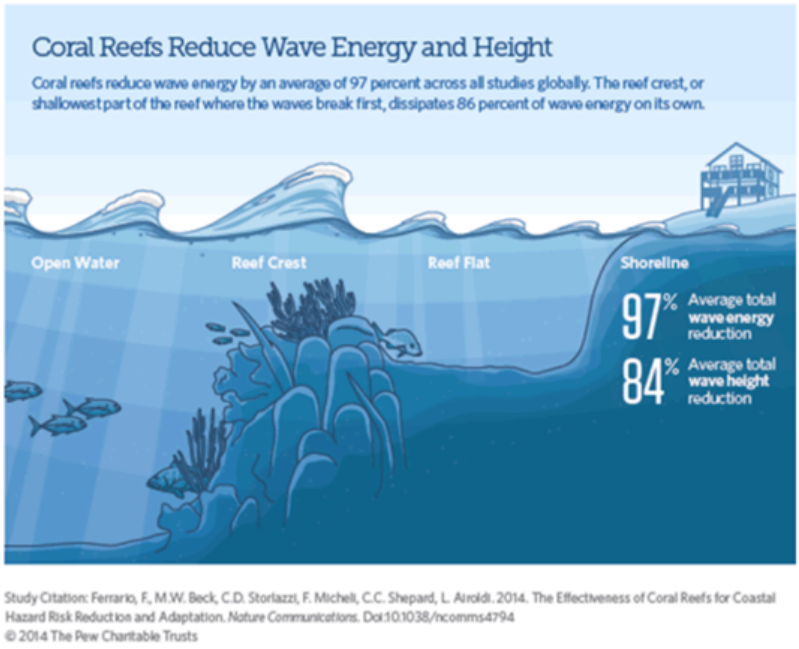


***Figure 7.*** *Depicts coral reefs decreasing wave height.*

3.1.5 Medical resources

Novel chemicals and medication may be found in coral reefs. Currently, certain coral species found on reefs generate chemical compounds that have been used in an approach to treating cardiovascular disease, ulcers, leukaemia, lymphoma, and skin cancer. Ongoingly numerous beneficial products are being derived such as an algae-based cancer treatment and a

painkiller taken from the venom in cone snails. Due to the multitude of reefs, immeasurable amounts remain undiscovered, meaning the loss of these valuable resources could impede future medical advancements. More than 50% of all new cancer drug research is focused on marine organisms found on coral reefs.

3.1.6 Education and Scientific Research

In summary, there would be a decrease in marine biodiversity as well as ripple impacts on human communities and the economy if coral reefs were to disappear. It is imperative that global efforts be made to conserve and protect coral reefs because of the interdependence of ecosystems and human dependence on healthy oceans.

### *3.2. Key justifications why coral reefs are vital to other marine life.*

It is estimated that about 25% of all known marine species rely on coral reefs for their survival.

3.2.1 Food

A vital source of nourishment for a variety of creatures is found within coral reefs. Numerous fish and invertebrate species feed on the reef ecosystem and add to the food chain in the surrounding marine environment as well as on the reef itself.

3.2.2 Shelter

One of the biodiverse ecosystems on Earth is the coral reef. They serve as a home to a staggering array of marine life, such as fish, molluscs, sponges, algae, and invertebrates. Because of the intricate structure of the reef, a wide variety of creatures can find hiding spots and niches.

3.2.3 Breeding

Coral reefs serve as a nursery and breeding habitats for numerous fish species. Young fish can find refuge and protection from predators because of the complex structure of the reefs. Many marine organisms are supported in their early life stages by the availability of food sources surrounding reefs.

## 4. Methods to prevent coral decay

In the long term, climate change is understandably and visibly more important. However, one person cannot halt climate change, but one can reduce human activities which are contributors thus causing negative effects on the coral reefs. We as human beings can take many courses of action to help protect our coral reefs and prevent their extinction. Researching this topic I found unsurprisingly that one of the major reasons coral reefs are dying is actually due to human activity.

4.1.1 Public Awareness Education on the topic.

Over time, even just being self-aware and knowledgeable about this issue might have a positive outcome. After decades of research, it was revealed that though scientists have developed the best suitable and effective sunscreen to protect your skin, the chemicals are extremely toxic for the reefs. What can seem like a negligible amount of this chemical was said to be enough to cause the bleaching of reefs. Thankfully, we can educate ourselves about this harmful chemical and choose a sunscreen without the ingredient oxybenzone as it is the one known to be toxic to corals.

4.1.2 Recycling

Littering is another major issue affecting the reefs. Human waste such as plastic: a nonbiodegradable, toxic material ends up in the ocean. This plastic debris can become entangled or ingested by marine life causing them to die. According to the United Nations, at least 800 species worldwide are affected. Up to 13 million metric tons of plastic end up in the ocean every year. This offsets the natural ecosystem and food chain.

Oil spills caused by ships are an element that when encountered by the coral, can kill or impede their reproduction, growth, behaviour, and development. The entire reef ecosystem can and will suffer from an oil spill.

4.1.3 -Reducing your carbon footprint

*Ocean acidification*

Another factor responsible for 'bleaching' is the increase in ocean acidification caused by the absorption of carbon dioxide (NOAA National Ocean Service 2021).

Ocean acidification, also referred to as the other effect of CO2 (Doney et al., 2009), because of changes in land use and the burning of fossil fuels, the concentration of carbon dioxide (CO2) in the atmosphere has been rising for almost 200 years, or since the industrial revolution. About 30% of the CO2 produced into the atmosphere is absorbed by the ocean, and as atmospheric CO2 levels rise, so do ocean CO2 levels. As per the United Nations Environment Programme (UNEP), there was an indication of the impact on coral reefs worldwide when the carbon dioxide level hit 390 ppm.

The concentration of hydrogen ions rises as a result of a sequence of chemical processes that take place when CO2 is absorbed by saltwater. As a result of this rise, carbonate ions are comparatively less common and the ocean becomes more acidic due to the formation of carbonic acid, which concentration leads to a reduction in the pH of seawater, making it more acidic.

Decreases in carbonate ions can make it more difficult for calcifying organisms like oysters, clams, sea urchins, shallow water corals, deep sea corals, and calcareous plankton to build and maintain shells and other calcium carbonate structures. These changes in ocean chemistry can also affect the behaviour of non-calcifying organisms, such as fish whose ability to detect predators is reduced in more acidic waters, which puts the entire food web at risk. Ocean acidification is affecting all of the world's oceans, including coastal estuaries and waterways. Many economies depend on fish and shellfish, and people around the world rely on the ocean for their daily sustenance.

*Deforestation*

In 2022 and ongoing in 2023, the unimaginable occurred, 11.8 million acres of the Amazon forest burnt between the months of January to September 2023 caused by selfish humans contributing to global warming for self-gain. The gas produced by the event of deforestation only leads to more destruction of our reef causing these underwater forests to further disintegrate. The reduced number of trees available to absorb CO2 from the atmosphere, through photosynthesis, results in higher concentrations of CO2 in the air, contributing to ocean acidification.

*Preventing ocean acidification*

The issue of ocean acidification is intricate and multidimensional, with significant ecological and socioeconomic ramifications. It will take international cooperation to cut carbon emissions and adopt sustainable methods to safeguard marine ecosystems in order to address the underlying causes of this phenomenon.

The most practical long-term approach is to reduce greenhouse gas emissions, which are the main cause of ocean acidification and climate change. Furthermore, it is imperative to make attempts to adjust to evolving circumstances. Examples of this include creating more robust aquaculture methods and putting marine conservation policies into place.

To help combat this issue it is essential to take initiative and reduce your carbon footprint. This can be done on an individual level by straightforward methods like:

1. Using energy-saving lightbulbs and appliances. When not in use, turn off the lights and gadgets.
2. Encourage the use of renewable energy sources, such as wind and solar energy. Install solar panels if you can, or ask your utility company to offer you a green energy choice.
3. Rather than driving your own car, consider taking the bus, carpooling, biking, or walking. Select electric or fuel-efficient cars if at all possible. To cut down on emissions from commuting, think about working from home or via telecommuting.
4. Minimise waste by material recycling, item reuse, and consumption reduction. Recycling lowers the quantity of garbage in landfills and the energy needed to produce new things.
5. Conserve water to reduce the energy associated with water treatment and distribution
6. Reduce your intake of meat or switch to a plant-based diet. The production of livestock contributes significantly to greenhouse gas emissions. Purchase seasonal, organic, and locally grown food to help promote sustainable farming methods.
7. When making purchases of goods and services, make educated decisions. Encourage the use of sustainable and eco-friendly products. Think about how your purchases, including the packaging, will affect the environment.
8. Minimise your flying because it emits a lot of carbon. When travelling, aim for buses or trains whenever possible.

It is an ongoing process that involves making mindful choices in various aspects of your life. These small individual changes, when multiplied across countries or even continents will have a meaningful impact on preserving the environment.

4.1.4 Sustainable fishing practices

Humans are overfishing in these areas and causing the food chain to become unbalanced. These fish have a symbiotic relationship with the coral. They help keep the underwater ecosystem stable as they eat the algae and parasites of the coral. Without them, it overwhelms the corals causing them to eventually die. (National Geographic 2019). While fishing, another factor causing the depletion of coral due to human activity is boats dragging anchors and nets along the ocean floor breaking and killing coral, destroying and damaging reefs.

### *4.2 How is the world preventing coral decay?*

4.2.1 Coral Restoration Programs

They have developed methods to deal with these problems such as Coral Vita, the world's first commercial, land-based coral farm. Coral farming is the process of carefully raising broken-off coral fragments and reintroducing them into the water once they have become mature enough to survive. This process has helped and continues to aid in the recovery of coral reefs.

4.2.2 National policy

Individuals can advocate to their governments to implement policies and laws that address the risk to coral reefs. This could include laws that restrict overfishing, lessen pollution and protect coral habitats. Further, it would be essential to tackle global struggles with climate change harming coral reefs where international cooperation is crucial.

The Coral Reef Conversation Act is currently one of the actions implemented in the development and management of sustainable use of coral reef ecosystems. They provide financial resources to aid in the preservation of reefs.

The Paris Agreement is an international treaty adopted in 2015 with the goal of addressing climate change on a global scale. Its primary objective is to limit the increase in global average temperature to well below 2 degrees Celsius above pre-industrial levels. The agreement embodies a cooperative and adaptable strategy to combat climate change, with countries cooperating to establish and meet their climate targets.

## 5. Is it already too late?

Despite the current threats, it is evidently not too late to salvage these underwater ecosystems, though the development of mankind has initiated a negative effect on the coral reefs. In the long term, these situations will result in irreversible consequences on the earth and will affect future generations. The Covid-19 pandemic (2020-2021), though it halted the efforts of key organization's operations from continuing to take action and attempt to save reefs, with underwater clean-ups. Without the interference of mankind and its toxic behaviour towards nature, the environment was able to replenish itself and begin thriving.

Within a few weeks, of the COVID-19 pandemic, the travel and other economic sector restrictions imposed by nations worldwide significantly reduced air pollution and greenhouse gas emissions. The abrupt shift provided scientists with a never-before-seen perspective of outcomes that would take years to attain under laws.

The scientists pointed out that the most unexpected finding was that, despite a 5.4% decrease in carbon dioxide (CO2) emissions in 2020, the amount of CO2 in the atmosphere grew at a roughly constant pace. Head of JPL's carbon department and research co-author David Schimel said, "You could immediately see a change in the growth rate of CO2 during previous socioeconomic disruptions, like the 1973 oil shortage." "We all anticipated seeing it this time as well.

First, although there was a notable 5.4% decrease in emissions, the increase in air concentrations was within the typical range of annual variation brought on by natural processes. Additionally, the ocean's absorption of CO2 from the atmosphere was less than it has been recently; this was likely due to an unanticipatedly quick reaction to the lower CO2 pressure in the air near the ocean's surface.

This gives us a glimpse of how prompt action could have favourable results. Coral reef recovery can be facilitated by international cooperation, governmental changes, and responsible personal decisions, despite the enormous obstacles.

Venice canals run clear, dolphins appear in Italy's waterways amid coronavirus lockdown. Picture: Getty/Twitter

***Figure 8.*** *Shows how with the lack of human activity wildlife beings to flourish once more.*

## 5. Conclusion

To sum up, the detrimental impacts of pollution and climate change on the planet's coral reefs pose a serious threat that necessitates immediate attention and coordinated measures on a global scale. The escalating effect of climate change, driven by the rise in greenhouse gas emissions fueled by the pollution of our planet due to human activity poses a threat to the survival of these underwater ecosystems. Therefore, it is essential that us, human beings, take the initiative by not only spreading awareness in the hope to combat this issue but also take the necessary steps to collectively preserve our ocean's coral reefs.

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